

# Module Catalog

*M.Sc. Environmental Engineering*

TUM School of Engineering and Design

Technische Universität München

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## Module Catalog: General Information and Notes to the Reader

### **What is the module catalog?**

One of the central components of the Bologna Process consists in the modularization of university curricula, that is, the transition of universities away from earlier seminar/lecture systems to a modular system in which thematically-related courses are bundled together into blocks, or modules.

This module catalog contains descriptions of all modules offered in the course of study.

Serving the goal of transparency in higher education, it provides students, potential students and other internal and external parties with information on the content of individual modules, the goals of academic qualification targeted in each module, as well as their qualitative and quantitative requirements.

### **Notes to the reader:**

#### **Updated Information**

An updated module catalog reflecting the current status of module contents and requirements is published every semester. The date on which the module catalog was generated in TUMonline is printed in the footer.

#### **Non-binding Information**

Module descriptions serve to increase transparency and improve student orientation with respect to course offerings. They are not legally-binding. Individual modifications of described contents may occur in praxis.

Legally-binding information on all questions concerning the study program and examinations can be found in the subject-specific academic and examination regulations (FPSO) of individual programs, as well as in the general academic and examination regulations of TUM (APSO).

#### **Elective modules**

Please note that generally not all elective modules offered within the study program are listed in the module catalog.

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| <b>[BV560023] Intelligent Transport Systems</b>   Intelligente<br>Verkehrssysteme [ITS]                                                                                                                                         | 368 - 370 |
| <b>[BV560024] Traffic Management</b>   Verkehrsmanagement [TM]                                                                                                                                                                  | 371 - 374 |
| <b>Elective Modules</b>   Wahlmodule                                                                                                                                                                                            | 375       |
| <b>[BGU56048] Traffic Data Collection and Analysis</b>   Verkehrsdaten -<br>Erfassung und Analyse [TD-C&A]                                                                                                                      | 375 - 376 |
| <b>[BGU56055] Autonomous Vehicles and Transportation Systems</b>  <br>Autonome Fahrzeuge und Verkehrsmittel [AVTS]                                                                                                              | 377 - 378 |
| <b>[BGU56056] Urban Ropeways</b>   Urbane Seilbahnen [URW]                                                                                                                                                                      | 379 - 380 |
| <b>[BGU68005] ICT-Enabled Business Models for Urban Mobility</b>   ICT-<br>unterstützte Unternehmensmodelle für urbane Mobilität [Business Models<br>for Urban Mobility]                                                        | 381 - 382 |
| <b>[BGU68006] Road Safety</b>   Straßenverkehrssicherheit [Road Safety]                                                                                                                                                         | 383 - 385 |
| <b>[BGU70006] Statistical Learning and Data Analytics for<br/>Transportation Systems</b>   Statistisches Lernen und Datenanalyse<br>für Verkehrssysteme [Statistical Learning and Data Analytics for<br>Transportation Systems] | 386 - 388 |
| <b>[BGU70007] Special Topics on Model Calibration</b>   Spezielle Themen<br>zur Modellkalibrierung [Special Topics on Transportation Model Calibration]                                                                         | 389 - 391 |
| <b>[BGU70008] Urban Transportation Systems: Operations Research<br/>and Emerging Mobility Technologies</b>   Urbane Verkehrssysteme:<br>Betriebsforschung und neue Mobilitätstechnologien [Urban Transportation<br>Systems]     | 392 - 394 |
| <b>[BV340019] Road and Rail Design</b>   Entwurf und Bemessung von<br>Straßen und Eisenbahnen                                                                                                                                   | 395 - 396 |
| <b>[BV520009] Project Appraisal and Planning Processes in<br/>Transportation</b>   Projektbewertung und Planungsprozesse im Verkehr                                                                                             | 397 - 399 |

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| <b>[ED150005] Modelling Tools and Practice Insight for Traffic Engineering</b>   Modellwerkzeuge und Einblick in die Praxis des Verkehrsingenieurwesens [MTPI]                                                                                           | 400 - 402 |
| <b>Field of Study 11: Water-Energy-Food Nexus</b>   Vertiefung 11: Water-Energy-Food Nexus                                                                                                                                                               | 403       |
| <b>Required Modules</b>   Pflichtmodule                                                                                                                                                                                                                  | 403       |
| <b>[BGU38038] Urban Water-Energy-Food Nexus</b>   Urban Water-Energy-Food Nexus [WEF Nexus]                                                                                                                                                              | 403 - 405 |
| <b>[BGU46038] Principles and Applications of Land Management</b>   Prinzipien und Anwendung von Landschaftsmanagement                                                                                                                                    | 406 - 408 |
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| <b>[WZ2720] Renewable Energy Technologies</b>   Renewable Energy Technologies                                                                                                                                                                            | 409 - 410 |
| <b>[WZ1065] Climate Change and Agriculture</b>   Klimawandel und Landwirtschaft                                                                                                                                                                          | 411 - 413 |
| <b>[BGU36010] Energy-Building-City</b>   Energie-Gebäude-Stadt                                                                                                                                                                                           | 414 - 416 |
| <b>[BGU38019] Anaerobic Processes and Energy Recovery</b>   Anaerobtechnik und Energierückgewinnung                                                                                                                                                      | 417 - 418 |
| <b>[BGU40035] Environment and Land Use Planning</b>   Umwelt- und Landnutzungsplanung                                                                                                                                                                    | 419 - 421 |
| <b>[BGU40057] Decision Support Systems</b>   Entscheidungsunterstützungssysteme [DSS]                                                                                                                                                                    | 422 - 424 |
| <b>[BGU40063] Land Management International - Theory and Practice</b>   Landmanagement International - Theorie und Praxis                                                                                                                                | 425 - 427 |
| <b>[BGU46029] Summer School of NeXus Water Food Energy</b>   Summer School zum NeXus Water Food Energy                                                                                                                                                   | 428 - 429 |
| <b>[BGU46036] Water Resources and Hydropower</b>   Wasserwirtschaft und Wasserkraft [WRHP]                                                                                                                                                               | 430 - 432 |
| <b>[BGU46039] Ethics in Science and Technology</b>   Ethik in Wissenschaft und Technologie                                                                                                                                                               | 433 - 434 |
| <b>[BGU54011] Integrated Water Resources Management</b>   Integriertes Wasserressourcen Management [IWRM]                                                                                                                                                | 435 - 437 |
| <b>[BGU66026] Shallow and Deep Geothermal Energy Use of Groundwater for environmental Engineers</b>   Flache und Tiefe Geothermie von Grundwassersystemen für Umweltingenieure                                                                           | 438 - 440 |
| <b>[BV170051] Energy Economics and Hydro Power</b>   Energiewirtschaft und Wasserkraftanlagen                                                                                                                                                            | 441 - 442 |
| <b>[CS0073] Circular Economy</b>   Circular Economy [CEC]                                                                                                                                                                                                | 443 - 445 |
| <b>[EI7467] Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country</b>   Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country [ProRESDC] | 446 - 448 |

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| <b>[POL62400] Environment and Climate Transformation</b>   Environment and Climate Transformation                                           | 449 - 451 |
| <b>[POL62500] The Ethics and Politics of Existential Global Risks</b>   The Ethics and Politics of Existential Global Risks                 | 452 - 454 |
| <b>[WI001255] Lecture Series Renewable Energy Systems in the Global South</b>   Ringvorlesung Erneuerbare Energiesysteme im Globalen Süden  | 455 - 457 |
| <b>[WZ1344] Urban Agriculture</b>   Urban Agriculture                                                                                       | 458 - 459 |
| <b>[WZ2730] Climate Change - Science, Impacts and Adaptation, Mitigation</b>   Climate Change - Science, Impacts and Adaptation, Mitigation | 460 - 461 |
| <b>[WZ4189] Fisheries and Aquatic Conservation</b>   Fisheries and Aquatic Conservation                                                     | 462 - 464 |
| <b>Personal Elective Modules</b>   Individuelle Wahlmodule                                                                                  | 465       |
| <b>[AR17041] Climate responsive Building II</b>   Klimagerechtes Bauen II                                                                   | 465 - 466 |
| <b>[AR17054] Conceptual Fire Prevention</b>   Konzeptioneller Brandschutz                                                                   | 467 - 468 |
| <b>[WI000091] Corporate Finance</b>   Corporate Finance                                                                                     | 469 - 470 |
| <b>[WI000285] Innovative Entrepreneurs - Leadership of High-Tech Companies</b>   Innovative Unternehmer - Führung von High-Tech Unternehmen | 471 - 473 |
| <b>[WI000286] Environmental and Natural Resource Economics</b>   Environmental and Natural Resource Economics                               | 474 - 475 |
| <b>[WZ1647] Remediation of Contaminated Sites - Lecture and Exercises</b>   Altlastensanierung - Vorlesung und Übungen                      | 476 - 478 |
| <b>[WZ4206] Material Flow Management and Applications</b>   Material Flow Management and Applications                                       | 479 - 480 |
| <b>[WZ6339] Applied River Restoration</b>   Angewandte Fließgewässerrenaturierung                                                           | 481 - 482 |
| <b>[WZ6332] Soils of the World: Properties and Protection</b>   Böden der Welt: Eigenschaften und Schutz                                    | 483 - 484 |
| <b>[AR30055] Automation &amp; Robotics in Construction</b>   Automatisierung und Robotik im Bauwesen [ARC]                                  | 485 - 487 |
| <b>[WZ6415] Applied Limnology</b>   Angewandte Limnologie (V+Ü)                                                                             | 488 - 489 |
| <b>[BGU900011] Partner University - Elective Module</b>   Partneruniversität - Wahlmodul                                                    | 490 - 491 |
| <b>[WZ2469] Limnology of Running Waters</b>   Limnologie der Fließgewässer                                                                  | 492 - 493 |
| <b>[WZ6115] Environmental Law</b>   Planungsbezogenes Umweltrecht                                                                           | 494 - 495 |
| <b>[WZ1561] Value Chain Economics</b>   Value Chain Economics                                                                               | 496 - 499 |
| <b>[WZ4198] Wildlife Management and Wildlife-Human Interactions</b>   Wildlife Management and Wildlife-Human Interactions                   | 500 - 501 |
| <b>[WI000021] Economics I - Microeconomics</b>   Volkswirtschaftslehre I - Mikroökonomie [ECON 1]                                           | 502 - 504 |



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| <b>[WI000021_E] Economics I - Microeconomics</b>   Economics I - Microeconomics [ECON 1]                                                                                                  | 505 - 506 |
| <b>[WI000023] Economics II - Macroeconomics</b>   Volkswirtschaftslehre II - Makroökonomie [VWL 2]                                                                                        | 507 - 508 |
| <b>[ED0152] Knowledge and Cognition (advanced topics)</b>   Erkenntnis und Kognition (vertieft)                                                                                           | 509 - 510 |
| <b>[WI000231] Asset Management</b>   Asset Management                                                                                                                                     | 511 - 513 |
| <b>[ED0218] Science and Technology Communication</b>   Wissenschafts- und Technikkommunikation                                                                                            | 514 - 515 |
| <b>[WZ6030] Compulsory Module</b>   Wahlmodul                                                                                                                                             | 516 - 517 |
| <b>[MCTS0036] Moderation (RESET)</b>   Moderation (RESET)                                                                                                                                 | 518 - 519 |
| <b>[AR20091] Supplementary Introduction to Urbanism</b>   Ergänzende Einführung Städtebau                                                                                                 | 520 - 522 |
| <b>[AR30002] Spatial Economy</b>   Raumökonomie [RÖKMA]                                                                                                                                   | 523 - 525 |
| <b>[AR30294] Climate Responsive Building I</b>   Klimagerechtes Bauen I                                                                                                                   | 526 - 527 |
| <b>[AR30309] Conservation of historical buildings today I</b>   Denkmalpflege heute I                                                                                                     | 528 - 529 |
| <b>[AR30320] Technoscience and the City: Advances in Urban Theory</b>   Technoscience and the City: Advances in Urban Theory                                                              | 530 - 532 |
| <b>[AR30331] Conservation of historical buildings today II</b>   Denkmalpflege heute II                                                                                                   | 533 - 534 |
| <b>[AR30386] European Mega City Regions</b>   European Mega City Regions [EMCR]                                                                                                           | 535 - 537 |
| <b>[BGU36008] Methods of Measurement</b>   Messtechnik Seminar                                                                                                                            | 538 - 539 |
| <b>[BGU36011] Seminar Climate-Culture-Building in Building Physics</b>   Seminar klima- und kulturgerechtes Bauen in der Bauphysik [Seminar Climate-Culture-Building in building physics] | 540 - 541 |
| <b>[BGU37016] Optimization of building materials for practical applications</b>   Anwendungsgerechte Optimierung mineralischer Baustoffe                                                  | 542 - 544 |
| <b>[BGU37019T2] Seminar - Ecology in Building and Construction</b>   Seminar Ökologisches Bauen                                                                                           | 545 - 547 |
| <b>[BGU38010] Advanced Water Treatment Engineering and Reuse</b>   Weitergehende Wasserbehandlung und Wasser Recycling                                                                    | 548 - 549 |
| <b>[BGU38011] Wastewater Conveyance Systems and Stormwater Management</b>   Bewirtschaftung von Kanalnetzen und Regenwassermanagement                                                     | 550 - 551 |
| <b>[BGU38014] Water and Wastewater Treatment Engineering</b>   Wasserversorgung, Wasseraufbereitung und Abwasserbehandlung                                                                | 552 - 554 |
| <b>[BGU38019] Anaerobic Processes and Energy Recovery</b>   Anaerobtechnik und Energierückgewinnung                                                                                       | 555 - 556 |
| <b>[BGU38021] Industrial Wastewater Treatment and Reuse</b>   Industrieabwasserreinigung und Wiederverwendung                                                                             | 557 - 558 |

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| <b>[BGU38023] Engineered Natural Treatment Systems</b>   Natürliche Aufbereitungsverfahren                                                                                                                         | 559 - 560 |
| <b>[BGU38024] Advanced Water Treatment and Anaerobic Processes</b>   Weitergehende Wasserbehandlung und Anaerobtechnik                                                                                             | 561 - 563 |
| <b>[BGU38025] Design and Operation of Wastewater Treatment Plants</b>   Planung und Betrieb von Kläranlagen                                                                                                        | 564 - 565 |
| <b>[BGU38028] Water Resource Recovery Process Simulation and Design</b>   Prozesssimulation und Design von Kläranlagen                                                                                             | 566 - 568 |
| <b>[BGU38030] Statistical-Stochastic Forecasts of the Structural and Operational Status of Drainage Systems</b>   Statistisch-stochastische Prognosen des baulich-betrieblichen Zustands von Entwässerungssystemen | 569 - 570 |
| <b>[BGU38031] Sanitation in the Global South</b>   Sanitäre Versorgung im globalen Süden                                                                                                                           | 571 - 573 |
| <b>[BGU38033] Planning the Urban Water-Energy-Food Nexus</b>   Urban Water-Energy-Food Nexus Planung                                                                                                               | 574 - 575 |
| <b>[BGU40035] Environment and Land Use Planning</b>   Umwelt- und Landnutzungsplanung                                                                                                                              | 576 - 578 |
| <b>[BGU41020] Fluid Mechanics and Transport Mechanisms</b>   Fluidmechanik und Transportmechanismen                                                                                                                | 579 - 581 |
| <b>[BGU44014T2] Computation in Engineering II</b>   Computergestützte Berechnungsverfahren in den Ingenieurwissenschaften II                                                                                       | 582 - 583 |
| <b>[BGU46021] Hydro Power and Energy Storage - Project Work</b>   Wasserkraft und Energiespeicherung - Projektarbeit                                                                                               | 584 - 585 |
| <b>[BGU46022] Hydraulics in Water Engineering</b>   Wasserbauhydraulik [HE]                                                                                                                                        | 586 - 587 |
| <b>[BGU46026] Alpine Hazards</b>   Alpine Naturgefahren [Ri+Kr]                                                                                                                                                    | 588 - 590 |
| <b>[BGU46028] Mathematical Modeling of Hydrodynamics and Water Quality in Coastal Regions</b>   Mathematische Modellierung der Hydrodynamik und Wasserqualität in Küstengebieten [COASTAL]                         | 591 - 592 |
| <b>[BGU46030] Ecological Modeling of Surface Waters</b>   Ökologische Modellierung für Oberflächengewässer [ANNA]                                                                                                  | 593 - 595 |
| <b>[BGU46032] Hydraulics in Water Engineering Laboratory</b>   Laborübung Wasserbauhydraulik [HWEL]                                                                                                                | 596 - 597 |
| <b>[BGU46033] Laboratory and Field Exercises at the Oberrach Lab</b>   Modelltechnische und flussbauliche Übungen an der Versuchsanstalt Oberrach [VAO_2016]                                                       | 598 - 599 |
| <b>[BGU46034] Hydraulic Machinery and Plants Laboratory</b>   Laborübung Hydraulische Maschinen und Anlagen                                                                                                        | 600 - 601 |
| <b>[BGU46036] Water Resources and Hydropower</b>   Wasserwirtschaft und Wasserkraft [WRHP]                                                                                                                         | 602 - 604 |
| <b>[BGU46038] Principles and Applications of Land Management</b>   Prinzipien und Anwendung von Landschaftsmanagement                                                                                              | 605 - 607 |

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| <b>[BGU46039] Ethics in Science and Technology</b>   Ethik in Wissenschaft und Technologie                                                                                               | 608 - 609 |
| <b>[BGU46040] Ocean and Wind Energy</b>   Meeres- und Windenergie [OWE]                                                                                                                  | 610 - 612 |
| <b>[BGU46041] Implementation of Water Policy and Water Legislation</b>   Umsetzung von Wasserpolitik und Wassergesetzgebung [GRA_SEM]                                                    | 613 - 615 |
| <b>[BGU46042] Modeling of Habitat for Fish and Invertebrates in Rivers</b>   Lebensraummodellierung für Fische und Wirbellose in Flüssen [HABSIM]                                        | 616 - 618 |
| <b>[BGU48029] Introduction to Photogrammetry and Remote Sensing</b>   Einführung in die Photogrammetrie und Fernerkundung [PRG]                                                          | 619 - 620 |
| <b>[BGU50007] Ground Water Handling and Sustainable Use of Geomaterials in Civil Construction</b>   Grundwassermanagement und nachhaltige Materialverwendung in der Geotechnik           | 621 - 623 |
| <b>[BGU50008] Geotechnical Issues in Environmental Engineering</b>   Geotechnische Fragestellungen im Umweltingenieurwesen                                                               | 624 - 626 |
| <b>[BGU52015] Visualization of Spatial Data in Transportation</b>   Visualisierung von Raum- und Verkehrsdaten                                                                           | 627 - 629 |
| <b>[BGU52016] Evaluation of Transport Projects and Policies</b>   Evaluation von Verkehrsprojekten und -programmen                                                                       | 630 - 631 |
| <b>[BGU54008T2] Hydrological and Environmental River Basin Modelling</b>   Hydrologische und ökologische Flussgebietsmodellierung [HERBM]                                                | 632 - 634 |
| <b>[BGU54009] Flood Risk and Flood Management</b>   Hochwasserrisiko und Hochwassermanagement [FRM]                                                                                      | 635 - 637 |
| <b>[BGU54010] Groundwater Hydraulics, Modelling and Management</b>   Grundwasser - Hydraulik, Modellierung und Management [GHMM]                                                         | 638 - 640 |
| <b>[BGU54011] Integrated Water Resources Management</b>   Integriertes Wasserressourcen Management [IWRM]                                                                                | 641 - 643 |
| <b>[BGU54013T2] Seminar in Rainfall-Runoff Modelling</b>   Seminar Niederschlags-Abfluss Modellierung [SRRM]                                                                             | 644 - 646 |
| <b>[BGU54015] Water Management at the Catchment Scale (Field trip to the Adige River Basin)</b>   Wassermanagement auf Einzugsgebietsebene (Exkursion in das Etsch Einzugsgebiet) [WMCS] | 647 - 648 |
| <b>[BGU54016] Process Based Modelling of Mesoscale Pre-alpine Catchments</b>   Prozessbasierte Modellierung mesoskaliger voralpiner Einzugsgebiete [MPAC]                                | 649 - 651 |
| <b>[BGU54019] Numerical Modeling of Water Demand and Supply in Arid Regions</b>   Numerische Modellierung von Wasserbedarf und -Versorgung in ariden Gebieten [OWHM]                     | 652 - 653 |
| <b>[BGU54021] Remote Sensing in Hydrology</b>   Fernerkundung in der Hydrologie [RSH]                                                                                                    | 654 - 656 |
| <b>[BGU54024] Uncertainty Quantification in Hydrology</b>   Unsicherheitbestimmung in der Hydrologie [UQH]                                                                               | 657 - 659 |

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| <b>[BGU54026] Urban Flood Modelling</b>   Modellierung städtischer Überschwemmungen [UFM]                                                                                                    | 660 - 661 |
| <b>[BGU56033] Freight Transport Concepts / Logistics</b>   Güterverkehrskonzepte / Logistik                                                                                                  | 662 - 663 |
| <b>[BGU56048] Traffic Data Collection and Analysis</b>   Verkehrsdaten - Erfassung und Analyse [TD-C&A]                                                                                      | 664 - 665 |
| <b>[BGU60015] Reliability for Engineering Systems</b>   Zuverlässigkeit von Systemen                                                                                                         | 666 - 667 |
| <b>[BGU60021] Risk Assessment and Reliability of Engineering Systems</b>   Risikobewertung und Systemzuverlässigkeit [RA&SR]                                                                 | 668 - 670 |
| <b>[BGU62039] Case Studies of Sustainable Urban Developments and Infrastructure</b>   Fallstudien nachhaltiger Quartiers-, Stadt- und Infrastrukturentwicklungen [FNQSI]                     | 671 - 674 |
| <b>[BGU62041] Sustainable Architecture, Urban and Landscape Planning - for Environmental Engineering</b>   Nachhaltige Architektur, Stadt- und Landschaftsplanung - für Umweltingenieurwesen | 675 - 678 |
| <b>[BGU62043] Aspects of Sustainable Urbanism</b>   Aspects of Sustainable Urbanism                                                                                                          | 679 - 680 |
| <b>[BGU62052] Renewable Energy Supply in Buildings</b>   Erneuerbare Energieversorgung von Gebäuden                                                                                          | 681 - 682 |
| <b>[BGU62053] Sustainable Lighting</b>   Nachhaltige Lichttechnik                                                                                                                            | 683 - 684 |
| <b>[BGU62059] Application of an Life Cycle Assessment for Civil Engineering</b>   Anwendung einer Lebenszyklusanalyse für Bauingenieurwesen                                                  | 685 - 686 |
| <b>[BGU66016] Hydrogeologic and Hydro Chemical Lab Course</b>   Hydrogeologisches Fluid- und Hydrochemisches Laborpraktikum                                                                  | 687 - 689 |
| <b>[BGU66022] Groundwater Hydraulics</b>   Grundwasserhydraulik                                                                                                                              | 690 - 692 |
| <b>[BGU66023D2] The Saturated and the Unsaturated Zone: Process Understanding and Modelling</b>   Die gesättigte und ungesättigte Zone: Prozessverständnis und Modellierung                  | 693 - 695 |
| <b>[BGU66024D2] Advanced Groundwater Modelling for Environmental Engineers</b>   Fortgeschrittene Grundwassermodellierung für Umweltingenieure                                               | 696 - 699 |
| <b>[BGU66025] Applied Hydrogeology for Environmental Engineers</b>   Hydrogeologie in der Praxis für Umweltingenieure                                                                        | 700 - 702 |
| <b>[BGU66026] Shallow and Deep Geothermal Energy Use of Groundwater for environmental Engineers</b>   Flache und Tiefe Geothermie von Grundwassersystemen für Umweltingenieure               | 703 - 705 |
| <b>[BGU66029] Transport of Contaminants in Groundwater for Environmental Engineers</b>   Transport von Schadstoffen im Grundwasser für Umweltingenieure                                      | 706 - 708 |

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| <b>[BGU66037] Case studies in Technical Hydrogeology</b>   Technische Hydrogeologie in der Praxis                                                                                                                 | 709 - 712 |
| <b>[BGU67001] Landslides</b>   Hangbewegungen                                                                                                                                                                     | 713 - 715 |
| <b>[BGU67003] Process analysis, Modelling and Mitigation of Alpine Hazards</b>   Prozessanalyse, Modellierung und Vorbeugung/ Schutzmaßnahmen für Alpine Naturgefahren [W-13]                                     | 716 - 719 |
| <b>[BGU68006] Road Safety</b>   Straßenverkehrssicherheit [Road Safety]                                                                                                                                           | 720 - 722 |
| <b>[BGU68007] Applied Transport Modeling</b>   Angewandte Verkehrsmodellierung [Applied transport modeling]                                                                                                       | 723 - 725 |
| <b>[BGU68007] Applied Transport Modeling</b>   Angewandte Verkehrsmodellierung [Applied transport modeling]                                                                                                       | 726 - 728 |
| <b>[BGU68009] Applied Transport Planning in Developing Countries</b>   Angewandte Verkehrsplanung in Entwicklungsländern                                                                                          | 729 - 730 |
| <b>[BGU68010] Object-Oriented Programming for Transport Engineers</b>   Objektorientiertes Programmieren für Verkehrsingenieure [Object-Oriented Programming for Transport Engineers]                             | 731 - 733 |
| <b>[BGU70002] Multimodal and Intermodal Freight Transport</b>   Multimodaler und intermodaler Güterverkehr [Multimodal and intermodal freight transport]                                                          | 734 - 735 |
| <b>[BGU70003] Optimisation for Transportation Systems</b>   Optimierung für Verkehrssysteme [Optimisation for Transportation Systems]                                                                             | 736 - 737 |
| <b>[BGU70004] Discrete Choice Methods for Transportation Systems Analysis</b>   Diskrete Wahlmethoden für Verkehrssystemanalyse                                                                                   | 738 - 740 |
| <b>[BGU70005] Transportation Economics</b>   Transportökonomie [Transportation Economics]                                                                                                                         | 741 - 742 |
| <b>[BGU70007] Special Topics on Model Calibration</b>   Spezielle Themen zur Modellkalibrierung [Special Topics on Transportation Model Calibration]                                                              | 743 - 745 |
| <b>[BGU70008] Urban Transportation Systems: Operations Research and Emerging Mobility Technologies</b>   Urbane Verkehrssysteme: Betriebsforschung und neue Mobilitätstechnologien [Urban Transportation Systems] | 746 - 748 |
| <b>[BV000018] Concrete and Masonry Structures Basic Module</b>   Massivbau Grundmodul                                                                                                                             | 749 - 751 |
| <b>[BV000063] System-Theoretical Principles of Project Management</b>   Systemtheoretische Grundlagen des Projektmanagements [GL_PM]                                                                              | 752 - 753 |
| <b>[BV000066] Bidding, Tendering and Billing</b>   Vergaberecht und Vergabeverfahren [VergR]                                                                                                                      | 754 - 755 |
| <b>[BV000082] Financing of Real Estate</b>   Immobilienfinanzierung [ImmoFin]                                                                                                                                     | 756 - 757 |
| <b>[BV000086] Town Planning</b>   Stadtplanung und Stadtentwicklung [StPl&Entw]                                                                                                                                   | 758 - 759 |
| <b>[BV020001] Continuum Mechanics</b>   Kontinuumsmechanik                                                                                                                                                        | 760 - 762 |
| <b>[BV030011] Computational Linear Algebra</b>   Computational Linear Algebra                                                                                                                                     | 763 - 764 |
| <b>[BV030012] Engineering Databases</b>   Datenbanken für Ingenieure [EngDB]                                                                                                                                      | 765 - 766 |

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| <b>[BV040005] Nature-oriented Care</b>   Naturnahe Bauweisen                                                          | 767 - 768 |
| <b>[BV040053] Computational Fluid Dynamics</b>   Numerische Methoden in der Fluidmechanik (CFD) [CFD]                 | 769 - 771 |
| <b>[BV070006] Practical Course Analysis and Testing</b>   Praktikum Analytik und Prüftechnik                          | 772 - 774 |
| <b>[BV110005] Seminar Building Physics</b>   Seminar Bauphysik                                                        | 775 - 776 |
| <b>[BV110006] Building Physics in Practice</b>   Bauphysik in der Praxis                                              | 777 - 778 |
| <b>[BV110050] Sustainability of Buildings</b>   Nachhaltigkeit von Gebäuden                                           | 779 - 780 |
| <b>[BV120003] Earthworks and Embankments</b>   Erd- und Dammbau                                                       | 781 - 782 |
| <b>[BV120008] Soil Mechanics Lab</b>   Bodenmechanisches Praktikum                                                    | 783 - 784 |
| <b>[BV120062] Advanced Geotechnics III</b>   Geotechnik Vertiefung III                                                | 785 - 787 |
| <b>[BV150050] Environmental Geology / Geochemistry</b>   Umweltgeologie / Geochemie                                   | 788 - 789 |
| <b>[BV170004] River Engineering and Hydromorphology</b>   Flussbau und Hydromorphologie [BUI River]                   | 790 - 791 |
| <b>[BV170009] International Water Rights and Politics</b>   Internationales Wasserrecht [GRAMBOW]                     | 792 - 793 |
| <b>[BV170051] Energy Economics and Hydro Power</b>   Energiewirtschaft und Wasserkraftanlagen                         | 794 - 795 |
| <b>[BV180004] Modelling of Water Quality in Aquatic Systems</b>   Modellierung der Wassergüte in aquatischen Systemen | 796 - 797 |
| <b>[BV180006] Hydrochemistry</b>   Hydrochemie                                                                        | 798 - 799 |
| <b>[BV180010] River Water Quality Management</b>   Gewässerschutz                                                     | 800 - 801 |
| <b>[BV180051] Hydrochemistry Lab</b>   Hydrochemie Praktikum                                                          | 802 - 803 |
| <b>[BV180071] Fundamentals of Urban Climate</b>   Urban Climate - Grundlagen                                          | 804 - 805 |
| <b>[BV210013] Urban und Regional Planning</b>   Stadt- und Regionalplanung                                            | 806 - 808 |
| <b>[BV320006] Modelling in structural analysis</b>   Modellbildung in der Baustatik [MB]                              | 809 - 810 |
| <b>[BV340001] Rail Design</b>   Rail Design                                                                           | 811 - 812 |
| <b>[BV340002] Road Design</b>   Road Design                                                                           | 813 - 814 |
| <b>[BV340008] Construction of Traffic Infrastructure</b>   Bau von Verkehrsinfrastruktur                              | 815 - 816 |
| <b>[BV340021] Air Transport and Airports</b>   Luftverkehr und Luftverkehrsanlagen                                    | 817 - 818 |
| <b>[BV360006] Acoustics incl. Acoustics Laboratory Practice</b>   Akustik inkl. Akustisches Laborpraktikum            | 819 - 821 |
| <b>[BV360011] Building Physics in Research</b>   Bauphysik in der Forschung                                           | 822 - 823 |
| <b>[BV380004] Microbiology of Groundwater Ecosystems</b>   Mikrobiologie von Grundwasserökosystemen                   | 824 - 827 |
| <b>[BV380009] Applications of Urban Climate</b>   Urban Climate - Anwendungen                                         | 828 - 829 |

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| <b>[BV400009] Land Management and Land Policy</b>   Bodenordnung und Bodenpolitik                                                   | 830 - 832 |
| <b>[BV400021] Instruments of Land Mobilization</b>   Instrumente der Bodenordnung und Landentwicklung                               | 833 - 834 |
| <b>[BV410005] Hydraulics Lab</b>   Hydraulik Praktikum                                                                              | 835 - 836 |
| <b>[BV410009] Numerical River Hydraulics</b>   Numerische Gerinnehydraulik [NRH]                                                    | 837 - 838 |
| <b>[BV410011] Hydro Project</b>   Hydroprojekt                                                                                      | 839 - 840 |
| <b>[BV410013] Fluid Mechanics and Turbulence</b>   Fluidmechanik und Turbulenz                                                      | 841 - 843 |
| <b>[BV410015] Energy Efficiency</b>   Energieeffizienz                                                                              | 844 - 845 |
| <b>[BV430005] Stability of Structures</b>   Stabilitätstheorie                                                                      | 846 - 847 |
| <b>[BV440004] Parallel Computing</b>   Paralleles Rechnen                                                                           | 848 - 850 |
| <b>[BV440007] Algorithms and Data Structures</b>   Algorithmen und Datenstrukturen                                                  | 851 - 852 |
| <b>[BV450005] Satellite Altimetry and Physical Oceanography</b>   Satellitenaltimetrie und Physikalische Ozeanografie [AltiOcean]   | 853 - 855 |
| <b>[BV460012] Rivers as an Ecosystem</b>   Fließgewässer als Lebensraum [KS_4]                                                      | 856 - 858 |
| <b>[BV460017] Hydro Power und Energy Storage</b>   Wasserkraft und Energiespeicherung [HPES]                                        | 859 - 860 |
| <b>[BV460018] Sustainable Water Resources Management</b>   Modelle für eine nachhaltige Wasserbewirtschaftung [SWRM]                | 861 - 862 |
| <b>[BV460019] Inland Navigation Management and Constructions</b>   Verkehrswasserbau und Wasserstraßen                              | 863 - 865 |
| <b>[BV500003] Unsaturated soil mechanics</b>   Mechanik ungesättigter Böden                                                         | 866 - 867 |
| <b>[BV500004] Environmental Geotechnics II</b>   Umweltgeotechnik II                                                                | 868 - 869 |
| <b>[BV520006] Transport Planning Master Module</b>   Vertiefungsmodul Verkehrsplanung                                               | 870 - 872 |
| <b>[BV530014] Landslide Mapping Course</b>   Hangbewegungskartierung                                                                | 873 - 876 |
| <b>[BV530023] Study Project "Prevention against Alpine Natural Hazards"</b>   Modellprojekt "Prävention gegen alpine Naturgefahren" | 877 - 879 |
| <b>[BV560005] Intelligent Vehicles</b>   Intelligente Fahrzeuge [IV]                                                                | 880 - 881 |
| <b>[BV560011] Governance</b>   Governance                                                                                           | 882 - 884 |
| <b>[BV560024] Traffic Management</b>   Verkehrsmanagement [TM]                                                                      | 885 - 888 |
| <b>[BV580008] Modelling of Environmental Effects in Transportation</b>   Modellieren von Umweltwirkungen im Verkehr [MoDEET]        | 889 - 891 |
| <b>[BV580010] Analysis Methods - Statistics and GIS</b>   Analysemethoden - Statistik und GIS                                       | 892 - 893 |
| <b>[BV600004] Structural Reliability</b>   Zuverlässigkeitstheorie                                                                  | 894 - 895 |
| <b>[BV600011] Engineering Data Analysis with Matlab</b>   Datenanalyse für IngenieurInnen mit Matlab                                | 896 - 897 |

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| <b>[BV610020] Computer Aided Traffic Engineering with Matlab  </b><br>Computerunterstützte Verkehrsplanung mit Matlab                                            | 898 - 899 |
| <b>[BV620006] Special Topics in Sustainable Design  </b> Sonderthemen des nachhaltigen Bauens                                                                    | 900 - 901 |
| <b>[BV620020] Case Studies of Sustainable Urban Developments and Infrastructure  </b> Fallstudien nachhaltiger Quartiers-, Stadt- und Infrastrukturentwicklungen | 902 - 904 |
| <b>[BV650002] Advanced Topics in Building Information Modeling  </b><br>Advanced Topics in Building Information Modeling [BIM.advanced]                          | 905 - 906 |
| <b>[BV660011] QV Groundwater Modelling 1  </b> QV Grundwassermodellierung 1                                                                                      | 907 - 908 |
| <b>[CH0141] Organic Environmental Chemistry  </b> Organische Umweltchemie                                                                                        | 909 - 910 |
| <b>[CLA10269] Communication and Personality  </b> Kommunikation und Persönlichkeit                                                                               | 911 - 912 |
| <b>[CLA10412] Technical Writing (Engineer Your Text!)  </b> Technical Writing (Engineer Your Text!)                                                              | 913 - 914 |
| <b>[CLA10450] When Engineers Become Managers  </b> Wenn aus Ingenieuren Manager werden                                                                           | 915 - 916 |
| <b>[CLA10813] Economic Thinking: Economics  </b> Volkswirtschaftlich Denken                                                                                      | 917 - 918 |
| <b>[CLA11108] Leadership  </b> Führung übernehmen                                                                                                                | 919 - 920 |
| <b>[CLA11301] Presentation Training with Video Feedback  </b><br>Präsentationstraining vor der Kamera                                                            | 921 - 922 |
| <b>[CLA11313] Conflict Management and Conducting Discussions  </b><br>Konfliktmanagement und Gesprächsführung                                                    | 923 - 924 |
| <b>[CLA11317] Interdisciplinary Lecture Series Environment: Politics and Society  </b> Ringvorlesung Umwelt: Politik und Gesellschaft                            | 925 - 926 |
| <b>[CLA20201] Complex Systems  </b> Komplexe Systeme                                                                                                             | 927 - 928 |
| <b>[CLA20424] Intercultural Encounters  </b> Interkulturelle Begegnungen                                                                                         | 929 - 930 |
| <b>[CLA20710] Global Diversity Training  </b> Global Diversity Training                                                                                          | 931 - 932 |
| <b>[CLA20910] Gender Competence as Core Qualification  </b><br>Genderkompetenz als Schlüsselqualifikation                                                        | 933 - 934 |
| <b>[CLA21008] Fundamental Principles of Globalisation  </b> Grundlagen der Globalisierungsforschung                                                              | 935 - 936 |
| <b>[CLA21213] Individual Change Management  </b> Individual Change Management                                                                                    | 937 - 938 |
| <b>[CLA21601] Ethics and Responsibility II  </b> Ethik und Verantwortung II                                                                                      | 939 - 940 |
| <b>[CLA30267] Communication and Presentation  </b> Kommunikation und Präsentation                                                                                | 941 - 942 |
| <b>[CLA30621] Environmental Chemicals and Environmental Justice  </b><br>Umweltchemikalien und ökologische Gerechtigkeit                                         | 943 - 944 |
| <b>[CLA30704] Thinking, Perceiving, and Knowing  </b> Denken, Erkennen und Wissen                                                                                | 945 - 946 |



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| <b>[CLA31900] Lecture Series Environment - TUM</b>   Vortragsreihe Umwelt - TUM                                                                   | 947 - 948   |
| <b>[CLA90142] Self-Competence - Intensive Course</b>   Selbstkompetenz - intensiv                                                                 | 949 - 951   |
| <b>[EI04004] Strategic Management for Engineers</b>   Strategic Management for Engineers                                                          | 952 - 953   |
| <b>[EI0699] Urban Energy Systems and modern infrastructure for cities</b>   Stadtenergiesysteme und moderne städtische Infrastruktur [UESMIC]     | 954 - 955   |
| <b>[EI1289] Electrical Engineering</b>   Elektrotechnik                                                                                           | 956 - 958   |
| <b>[EI74831] Project Lab Renewable and Sustainable Energy Systems</b>   Project Lab Renewable and Sustainable Energy Systems [PropENS]            | 959 - 961   |
| <b>[EI7513] Ecomanagement and Life Cycle Analysis</b>   Umweltmanagement - Ökoauditierung                                                         | 962 - 963   |
| <b>[EI7605] Gas Sensing in Biomedical Applications</b>   Gassensorik für biomedizinische Anwendungen [Gas sensing for biomedical applications]    | 964 - 965   |
| <b>[EI80004] Sustainable Mobility</b>   Sustainable Mobility [SuMo]                                                                               | 966 - 968   |
| <b>[MW0219] Project Management for Engineers</b>   Projektmanagement für Ingenieure                                                               | 969 - 970   |
| <b>[MW1535] Introduction to Patent, Trademark and Design Law for Engineers</b>   Patent-, Marken- und Musterrecht für Ingenieure: Eine Einführung | 971 - 972   |
| <b>[MW2149] Introduction to Wind Energy</b>   Introduction to Wind Energy                                                                         | 973 - 975   |
| <b>[MW2152] Modeling, Control and Design of Wind Energy Systems</b>   Modeling, Control and Design of Wind Energy Systems                         | 976 - 978   |
| <b>[POL23200] Environmental Politics in International Comparison</b>   Umweltpolitik im internationalen Vergleich                                 | 979 - 981   |
| <b>[POL40100] Introductory Lecture: Politics and Technology</b>   Ringvorlesung: Politics & Technology                                            | 982 - 983   |
| <b>[POL60700] Democracy in the Digital Age</b>   Democracy in the Digital Age                                                                     | 984 - 985   |
| <b>[POL62200] Energy Transformation</b>   Energy Transformation                                                                                   | 986 - 987   |
| <b>[POL62400] Environment and Climate Transformation</b>   Environment and Climate Transformation                                                 | 988 - 990   |
| <b>[POL62500] The Ethics and Politics of Existential Global Risks</b>   The Ethics and Politics of Existential Global Risks                       | 991 - 993   |
| <b>[POL70070] Ethics of Technology</b>   Ethics of Technology                                                                                     | 994 - 995   |
| <b>[SZ0211] Chinese A2.1</b>   Chinesisch A2.1                                                                                                    | 996 - 997   |
| <b>[SZ0212] Chinese A2.2</b>   Chinesisch A2.2                                                                                                    | 998 - 999   |
| <b>[SZ0303] German as a Foreign Language A2.1</b>   Deutsch als Fremdsprache A2.1                                                                 | 1000 - 1001 |
| <b>[SZ03031] Intensive Course German as a Foreign Language A2.1</b>   Blockkurs Deutsch als Fremdsprache A2.1                                     | 1002 - 1003 |

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| <b>[SZ0304] German as a Foreign Language A2.2</b>   Deutsch als Fremdsprache A2.2                                                                                                                                                       | 1004 - 1005 |
| <b>[SZ03041] Intensive Course German as a Foreign Language A2.2</b>   Blockkurs Deutsch als Fremdsprache A2.2                                                                                                                           | 1006 - 1007 |
| <b>[SZ0314] German as a Foreign Language B2+C1: Kommunikation at work: German for Internship and Job</b>   Deutsch als Fremdsprache B2+C1: Kommunikation am Arbeitsplatz: Deutsch für Praktikum und Beruf                               | 1008 - 1010 |
| <b>[SZ0322] German as a Foreign Language A2.1 plus A2.2</b>   Deutsch als Fremdsprache A2.1 plus A2.2                                                                                                                                   | 1011 - 1012 |
| <b>[SZ0331] German for Engineers C1</b>   Deutsch für Ingenieur/innen C1                                                                                                                                                                | 1013 - 1014 |
| <b>[SZ0332] German as a Foreign Language B2+C1 - Intercultural Communication Skills - "Working as an Engineer in Germany"</b>   Deutsch als Fremdsprache B2+C1: Interkulturelle Kommunikation - Als IngenieurIn in Deutschland arbeiten | 1015 - 1016 |
| <b>[SZ0403] English - Academic Presentation Skills C1 - C2</b>   Englisch - Academic Presentation Skills C1 - C2                                                                                                                        | 1017 - 1018 |
| <b>[SZ0406] English - Writing Academic Research Papers C2</b>   Englisch - Writing Academic Research Papers C2                                                                                                                          | 1019 - 1020 |
| <b>[SZ0422-1] English - Jobline B2</b>   Englisch - Jobline B2                                                                                                                                                                          | 1021 - 1022 |
| <b>[SZ0442] English - The Science of Science Fiction C1</b>   Englisch - The Science of Science Fiction C1                                                                                                                              | 1023 - 1024 |
| <b>[SZ0471] English - Intensive Thesis Writers' Workshop C2</b>   Englisch - Intensive Thesis Writers' Workshop C2                                                                                                                      | 1025 - 1026 |
| <b>[SZ0502] French A1.2</b>   Französisch A1.2                                                                                                                                                                                          | 1027 - 1028 |
| <b>[SZ0503] French A2.1</b>   Französisch A2.1                                                                                                                                                                                          | 1029 - 1031 |
| <b>[SZ0504] French A2.2</b>   Französisch A2.2                                                                                                                                                                                          | 1032 - 1033 |
| <b>[SZ0505] French B1.1</b>   Französisch B1.1                                                                                                                                                                                          | 1034 - 1035 |
| <b>[SZ0507] French B2 - French for the profession</b>   Französisch B2 - Le français pour la profession                                                                                                                                 | 1036 - 1037 |
| <b>[SZ0511] French B2/C1 - France currently</b>   Französisch B2/C1 - La France actuelle                                                                                                                                                | 1038 - 1039 |
| <b>[SZ0515] French C1 - Upper Conversation Course</b>   Französisch C1 - Cours de conversation supérieure                                                                                                                               | 1040 - 1042 |
| <b>[SZ0606] Italian A2.1</b>   Italienisch A2.1                                                                                                                                                                                         | 1043 - 1044 |
| <b>[SZ0607] Italian A2.1 + A2.2 - Intensive</b>   Italienisch A2.1 + A2.2 - Intensiv                                                                                                                                                    | 1045 - 1046 |
| <b>[SZ0608] Italian A2.2</b>   Italienisch A2.2                                                                                                                                                                                         | 1047 - 1048 |
| <b>[SZ0609] Italian B1.1</b>   Italienisch B1.1                                                                                                                                                                                         | 1049 - 1050 |
| <b>[SZ0719] Japanese A2.1 + A2.2</b>   Japanisch A2.1 + A2.2                                                                                                                                                                            | 1051 - 1052 |
| <b>[SZ0806] Portuguese A2.1</b>   Portugiesisch A2.1                                                                                                                                                                                    | 1053 - 1055 |
| <b>[SZ08061] Intensive Course Portuguese A2.1</b>   Blockkurs Portugiesisch A2.1                                                                                                                                                        | 1056        |
| <b>[SZ0807] Portuguese A2.2</b>   Portugiesisch A2.2                                                                                                                                                                                    | 1057 - 1059 |

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| <b>[SZ0809] Portuguese B1.1   Portugiesisch B1.1</b>                                                                                     | 1060 - 1062 |
| <b>[SZ0903] Russian A2.1   Russisch A2.1</b>                                                                                             | 1063 - 1064 |
| <b>[SZ0904] Russian A2.2   Russisch A2.2</b>                                                                                             | 1065 - 1066 |
| <b>[SZ1003] Swedish B1   Schwedisch B1</b>                                                                                               | 1067 - 1068 |
| <b>[SZ1202] Spanish A2.1   Spanisch A2.1</b>                                                                                             | 1069 - 1071 |
| <b>[SZ1203] Spanish A2.2   Spanisch A2.2</b>                                                                                             | 1072 - 1074 |
| <b>[SZ12031] Spanish A2.1 + A2.2   Spanisch A2.1 + A2.2</b>                                                                              | 1075 - 1076 |
| <b>[SZ1209] Spanish C1 - current issues in Spain and Latin America  </b><br>Spanisch C1 - La actualidad en España y América Latina       | 1077 - 1079 |
| <b>[SZ1212] Spanish C1 - Spain and Latin America - Yesterday and Today  </b><br>Spanisch C1 - España y América Latina ayer y hoy         | 1080 - 1081 |
| <b>[SZ1216] Spanish B1.2   Spanisch B1.2</b>                                                                                             | 1082 - 1083 |
| <b>[SZ1217] Spanish B2.2   Spanisch B2.2</b>                                                                                             | 1084 - 1086 |
| <b>[SZ1218] Spanish B1.1   Spanisch B1.1</b>                                                                                             | 1087 - 1088 |
| <b>[SZ1225] Spanish B1.1 + B1.2   Spanisch B1.1 + B1.2</b>                                                                               | 1089 - 1090 |
| <b>[SZ1228] Spanish B2 - Spanish in Science and Technology   Spanisch</b><br>B2 - Español para la Ciencia und Tecnología                 | 1091 - 1092 |
| <b>[SZ1502] Danish A2   Dänisch A2</b>                                                                                                   | 1093 - 1094 |
| <b>[SZ1702] Norwegian A2   Norwegisch A2</b>                                                                                             | 1095 - 1096 |
| <b>[SZ1703] Norwegian B1   Norwegisch B1</b>                                                                                             | 1097 - 1098 |
| <b>[WI000946] Energy Markets I   Energy Markets I</b>                                                                                    | 1099 - 1101 |
| <b>[WI001057_E] Cost Accounting   Cost Accounting</b>                                                                                    | 1102 - 1103 |
| <b>[WI001058] Foundations of Entrepreneurial &amp; Ethical Business  </b><br>Foundations of Entrepreneurial & Ethical Business           | 1104 - 1106 |
| <b>[WI001072] Corporate Sustainability   Corporate Sustainability [Corp Sust</b><br>BC]                                                  | 1107 - 1109 |
| <b>[WI001122] Introduction to Business Law (MiM)   Introduction to Business</b><br>Law (MiM) [BusLawMiM]                                 | 1110 - 1111 |
| <b>[WI001125] Energy Markets II   Energy Markets II</b>                                                                                  | 1112 - 1114 |
| <b>[WI001129] Marketing and Innovation Management (MiM)   Marketing</b><br>and Innovation Management (MiM)                               | 1115 - 1117 |
| <b>[WI001131] Production and Logistics (MiM)   Production and Logistics</b><br>(MiM)                                                     | 1118 - 1120 |
| <b>[WI001138] Investment and Financial Management (MiM)   Investment</b><br>and Financial Management (MiM) [IaF]                         | 1121 - 1122 |
| <b>[WI001172] Core Topic: Politics &amp; Governance   Core Topic: Politics &amp;</b><br>Governance                                       | 1123 - 1125 |
| <b>[WI001185] Entrepreneurial, Strategic, and International Management  </b><br>Entrepreneurial, Strategic, and International Management | 1126 - 1129 |
| <b>[WI001204] Economics of Water Use, Regulation and Markets  </b><br>Economics of Water Use, Regulation and Markets                     | 1130 - 1132 |
| <b>[WI001223] Challenges in Energy Markets   Challenges in Energy Markets</b>                                                            | 1133 - 1134 |

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| <b>[WZ1082] Fish Biology and Aquaculture</b>   Fischbiologie und Aquakultur                                                                                                        | 1135 - 1137 |
| <b>[WZ1171] Climate change related challenges in sewage treatment biology and engineering ecology</b>   Klimabedingte Herausforderungen für Abwasserbiologie und Ingenieurökologie | 1138 - 1140 |
| <b>[WZ1171] Climate change related challenges in sewage treatment biology and engineering ecology</b>   Klimabedingte Herausforderungen für Abwasserbiologie und Ingenieurökologie | 1141 - 1143 |
| <b>[WZ1223] Climate, Climate Change and Land Use</b>   Klima, Klimawandel und Landnutzung                                                                                          | 1144 - 1145 |
| <b>[WZ1590] Climate Change Economics</b>   Climate Change Economics                                                                                                                | 1146 - 1148 |
| <b>[WZ1821] Natural Resources - Traits, Management and Theory of Sustainability</b>   Natural Resources - Traits, Management and Theory of Sustainability                          | 1149 - 1150 |
| <b>[WZ1825] Soil Science</b>   Bodenkunde                                                                                                                                          | 1151 - 1153 |
| <b>[WZ2673] Basics Aquatic Ecology and Conservation</b>   Grundlagen Ökologie und Schutz von Gewässersystemen                                                                      | 1154 - 1155 |
| <b>[WZ2733] Introduction to Soil Science</b>   Introduction to Soil Science                                                                                                        | 1156 - 1157 |
| <b>[WZ2734] Soil Protection</b>   Soil Protection                                                                                                                                  | 1158 - 1159 |
| <b>[WZ2735] World Soil Resources</b>   World Soil Resources                                                                                                                        | 1160 - 1161 |
| <b>[WZ4229] Development and Application of Ecological Simulation Models</b>   Entwicklung und Anwendung ökologischer Simulationsmodelle                                            | 1162 - 1164 |
| <b>[WZ6108] Instruments of Spatial Planning</b>   Planungsinstrumente der Landschaftsplanung                                                                                       | 1165 - 1167 |
| <b>[WZ8100] Fundamentals of Climate Change</b>   Fundamentals of Climate Change                                                                                                    | 1168 - 1169 |
| <b>Cross Cutting Methods</b>   Fächerübergreifende Methoden                                                                                                                        | 1170        |
| <b>[BGU900013] Partner University - Elective Module</b>   Partneruniversität - Wahlmodul                                                                                           | 1170 - 1171 |
| <b>[BGU38013] Technical Communication Skills in Water and Wastewater Treatment Engineering</b>   Präsentationstechniken anhand ausgewählter Kapitel der Siedlungswasserwirtschaft  | 1172 - 1173 |
| <b>[BGU38018] Planning Processes and Clearance According to German and European Law</b>   Planungs- und Genehmigungsverfahren nach deutschem und europäischem Wasserrecht          | 1174 - 1175 |
| <b>[BGU43012T2] Technical Acoustics</b>   Technische Akustik                                                                                                                       | 1176 - 1178 |
| <b>[BGU43025] Vibroacoustics</b>   Vibroakustik                                                                                                                                    | 1179 - 1181 |
| <b>[BGU43026] Modelling and Simulation in Structural Mechanics</b>   Modellierung und Simulation in der Strukturdynamik                                                            | 1182 - 1183 |
| <b>[BGU44013T2] Computation in Engineering I</b>   Computergestützte Berechnungsverfahren in den Ingenieurwissenschaften I                                                         | 1184 - 1186 |
| <b>[BGU45037] Introduction to Earth System Science</b>   Einführung in die Erdsystemforschung                                                                                      | 1187 - 1189 |

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| <b>[BGU46029] Summer School of NeXus Water Food Energy</b>   Summer School zum NeXus Water Food Energy                                         | 1190 - 1191 |
| <b>[BGU60015] Reliability for Engineering Systems</b>   Zuverlässigkeit von Systemen                                                           | 1192 - 1193 |
| <b>[BGU60018] Estimation of Rare Events and Failure Probabilities</b>   Abschätzung von seltenen Ereignissen und Versagenswahrscheinlichkeiten | 1194 - 1196 |
| <b>[BGU60019] Stochastic Finite Element Methods</b>   Stochastische Finite Elemente Methode [SFEM]                                             | 1197 - 1199 |
| <b>[BGU60021] Risk Assessment and Reliability of Engineering Systems</b>   Risikobewertung und Systemzuverlässigkeit [RA&SR]                   | 1200 - 1202 |
| <b>[BGU62059] Application of an Life Cycle Assessment for Civil Engineering</b>   Anwendung einer Lebenszyklusanalyse für Bauingenieurwesen    | 1203 - 1204 |
| <b>[BGU65006] Professional Software Development</b>   Professionelle Softwareentwicklung [ProSD]                                               | 1205 - 1206 |
| <b>[BGU65009] Artificial Intelligence in Engineering</b>   Künstliche Intelligenz im Ingenieurwesen [AI]                                       | 1207 - 1208 |
| <b>[BGU68002] Research Design: How to tackle a Master's Thesis</b>   Wissenschaftstheorie: Bewältigen einer Master Thesis [Research Design]    | 1209 - 1210 |
| <b>[BV000063] System-Theoretical Principles of Project Management</b>   Systemtheoretische Grundlagen des Projektmanagements [GL_PM]           | 1211 - 1212 |
| <b>[BV000122] Introduction into Technical Acoustics</b>   Einführung in die Technische Akustik                                                 | 1213 - 1215 |
| <b>[BV020007] Boundary Element Method</b>   Randelementmethode                                                                                 | 1216 - 1217 |
| <b>[BV030004] Software Lab</b>   Software Lab                                                                                                  | 1218 - 1220 |
| <b>[BV250050] As-built Surveying and geodetical Monitoring</b>   Baubestandsaufnahme und Bauwerksüberwachung                                   | 1221 - 1222 |
| <b>[BV360009] Life-cycle Assessment</b>   Ökobilanzierung                                                                                      | 1223 - 1225 |
| <b>[BV400016] Scientific Paper Writing</b>   Selbständig wissenschaftlich Arbeiten                                                             | 1226 - 1227 |
| <b>[BV430002] Integral Transform Methods</b>   Integraltransformationmethoden                                                                  | 1228 - 1230 |
| <b>[BV430008] Structural Dynamics</b>   Baudynamik                                                                                             | 1231 - 1233 |
| <b>[BV470002] Geo Web Services</b>   Geo Web Services                                                                                          | 1234 - 1235 |
| <b>[BV470003] Harmonisation of Geospatial Data</b>   Geodatenharmonisierung                                                                    | 1236 - 1237 |
| <b>[BV470015] Geodatabases</b>   Geodatenbanken                                                                                                | 1238 - 1239 |
| <b>[BV470016] Advanced GIS for Environmental Engineering - Theory</b>   Advanced GIS für Umweltingenieure - Theorie                            | 1240 - 1241 |
| <b>[BV470018] Spatiotemporal Analyses in GIS</b>   Raumzeitliche Analyse in GIS                                                                | 1242 - 1243 |
| <b>[BV480006] Digital Image Processing for Environmental Engineering</b>   Digitale Bildverarbeitung für Umweltingenieure [IP]                 | 1244 - 1245 |

|                                                                                                                                                                                                                                                          |             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| <b>[BV480007] Understanding Images - Basics</b>   Bildverstehen - Grundlagen                                                                                                                                                                             | 1246 - 1247 |
| <b>[BV480016] Introduction to Photogrammetry, Remote Sensing and Image Processing</b>   Einführung in die Photogrammetrie, Fernerkundung und Bildverarbeitung [PRC+IPC]                                                                                  | 1248 - 1250 |
| <b>[BV480018] Applied Remote Sensing</b>   Angewandte Fernerkundung [FEA]                                                                                                                                                                                | 1251 - 1252 |
| <b>[BV550025] System-Theoretical Principles of Risk Management for Business Processes and Real Estate Business Processes</b>   Systemtheoretische Grundlagen des Risikomanagement in der Bau- und Immobilienwirtschaft [RM_Baulmmo]                      | 1253 - 1254 |
| <b>[BV600001] Risk Analysis</b>   Risikoanalyse [RA1]                                                                                                                                                                                                    | 1255 - 1257 |
| <b>[ED110046] Internet of Things in the Built Environment</b>   Internet der Dinge in der gebauten Umwelt                                                                                                                                                | 1258 - 1260 |
| <b>[ED110059] Geokinematics</b>   Geokinematik                                                                                                                                                                                                           | 1261 - 1263 |
| <b>[EI7467] Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country</b>   Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country [ProRESDC] | 1264 - 1266 |
| <b>[EI74831] Project Lab Renewable and Sustainable Energy Systems</b>   Project Lab Renewable and Sustainable Energy Systems [PropENS]                                                                                                                   | 1267 - 1269 |
| <b>[MW1475] Renewable Energy Technology 1</b>   Regenerative Energiesysteme 1 [RET I]                                                                                                                                                                    | 1270 - 1272 |
| <b>[MW1476] Renewable Energy Technology 2</b>   Regenerative Energiesysteme 2 [RET II]                                                                                                                                                                   | 1273 - 1275 |
| <b>[WI001255] Lecture Series Renewable Energy Systems in the Global South</b>   Ringvorlesung Erneuerbare Energiesysteme im Globalen Süden                                                                                                               | 1276 - 1278 |
| <b>[WZ8088] Climate Change</b>   Climate Change                                                                                                                                                                                                          | 1279 - 1280 |
| <b>[WZ8100] Fundamentals of Climate Change</b>   Fundamentals of Climate Change                                                                                                                                                                          | 1281 - 1282 |
| <b>DTU Program - TUM Modules</b>   DTU Programm - TUM Module                                                                                                                                                                                             | 1283        |
| <b>Required Modules</b>   Prüfungsmodule                                                                                                                                                                                                                 | 1283        |
| <b>[BGU900011] Partner University - Elective Module</b>   Partneruniversität - Wahlmodul                                                                                                                                                                 | 1283 - 1284 |
| <b>[BGU900011] Partner University - Elective Module</b>   Partneruniversität - Wahlmodul                                                                                                                                                                 | 1285 - 1286 |
| <b>[BGU900012] Partner University - Elective Module</b>   Partneruniversität - Wahlmodul                                                                                                                                                                 | 1287 - 1288 |
| <b>[BGU38014] Water and Wastewater Treatment Engineering</b>   Wasserversorgung, Wasseraufbereitung und Abwasserbehandlung                                                                                                                               | 1289 - 1291 |
| <b>[BGU38021] Industrial Wastewater Treatment and Reuse</b>   Industrieabwasserreinigung und Wiederverwendung                                                                                                                                            | 1292 - 1293 |
| <b>[BGU38023] Engineered Natural Treatment Systems</b>   Natürliche Aufbereitungsverfahren                                                                                                                                                               | 1294 - 1295 |

|                                                                                                                                  |             |
|----------------------------------------------------------------------------------------------------------------------------------|-------------|
| <b>[BGU38024] Advanced Water Treatment and Anaerobic Processes  </b><br>Weitergehende Wasserbehandlung und Anaerobtechnik        | 1296 - 1298 |
| <b>[BGU38028] Water Resource Recovery Process Simulation and Design  </b><br>Prozesssimulation und Design von Kläranlagen        | 1299 - 1301 |
| <b>[BGU46026] Alpine Hazards  </b> Alpine Naturgefahren [Ri+Kr]                                                                  | 1302 - 1304 |
| <b>[BGU46032] Hydraulics in Water Engineering Laboratory  </b> Laborübung<br>Wasserbauhydraulik [HWEL]                           | 1305 - 1306 |
| <b>[BGU46034] Hydraulic Machinery and Plants Laboratory  </b> Laborübung<br>Hydraulische Maschinen und Anlagen                   | 1307 - 1308 |
| <b>[BGU46035] Hydraulic Engineering and Hydromorphology  </b><br>Wasserbauhydraulik und Hydromorphologie [HEHM]                  | 1309 - 1311 |
| <b>[BGU46036] Water Resources and Hydropower  </b> Wasserwirtschaft und<br>Wasserkraft [WRHP]                                    | 1312 - 1314 |
| <b>[BGU46038] Principles and Applications of Land Management  </b><br>Prinzipien und Anwendung von Landschaftsmanagement         | 1315 - 1317 |
| <b>[BGU46039] Ethics in Science and Technology  </b> Ethik in Wissenschaft<br>und Technologie                                    | 1318 - 1319 |
| <b>[BGU46040] Ocean and Wind Energy  </b> Meeres- und Windenergie [OWE]                                                          | 1320 - 1322 |
| <b>[BGU46040] Ocean and Wind Energy  </b> Meeres- und Windenergie [OWE]                                                          | 1323 - 1325 |
| <b>[BGU54009] Flood Risk and Flood Management  </b> Hochwasserrisiko und<br>Hochwassermanagement [FRM]                           | 1326 - 1328 |
| <b>[BGU60013] Risk Assessment  </b> Risikobewertung [RA2]                                                                        | 1329 - 1331 |
| <b>[BGU60015] Reliability for Engineering Systems  </b> Zuverlässigkeit von<br>Systemen                                          | 1332 - 1333 |
| <b>[BV170009] International Water Rights and Politics  </b> Internationales<br>Wasserrecht [GRAMBOW]                             | 1334 - 1335 |
| <b>[BV180006] Hydrochemistry  </b> Hydrochemie                                                                                   | 1336 - 1337 |
| <b>[BV380004] Microbiology of Groundwater Ecosystems  </b> Mikrobiologie<br>von Grundwasserökosystemen                           | 1338 - 1341 |
| <b>[BV470017] Advanced GIS for Environmental Engineering - Applications  </b><br>Advanced GIS für Umweltingenieure - Anwendungen | 1342 - 1343 |
| <b>[BV470018] Spatiotemporal Analyses in GIS  </b> Raumzeitliche Analyse in<br>GIS                                               | 1344 - 1345 |
| <b>[BV600001] Risk Analysis  </b> Risikoanalyse [RA1]                                                                            | 1346 - 1348 |
| <b>[MW1475] Renewable Energy Technology 1  </b> Regenerative<br>Energiesysteme 1 [RET I]                                         | 1349 - 1351 |
| <b>[MW1476] Renewable Energy Technology 2  </b> Regenerative<br>Energiesysteme 2 [RET II]                                        | 1352 - 1354 |
| <b>Project Studies  </b> Projektstudium                                                                                          | 1355        |
| <b>[BGU900035] Partner University DTU - Project Studies  </b><br>Partneruniversität DTU - Projektstudium                         | 1355 - 1356 |
| <b>Master's Thesis  </b> Master Thesis                                                                                           | 1357        |





## Module List | Modulkatalog

### Field of Study 1: Urban Water Engineering | Vertiefung 1: Urban Water Engineering

#### Required Modules | Pflichtmodule

#### Module Description

### BGU38014: Water and Wastewater Treatment Engineering | Wasserversorgung, Wasseraufbereitung und Abwasserbehandlung

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a written exam of 120 minutes duration.

Through theoretical questions students prove that they understand the individual stages for the elimination of wastewater constituents, the basics of water supply and wastewater management systems as well as necessity and feasibility of wastewater treatment methods, especially of municipal wastewater. Through application-oriented tasks, the students show that they can analyze resource management in the field of wastewater treatment, the performance of related systems, as well as location factors for water technology systems and can critically evaluate various conventional water and wastewater treatment techniques, taking into account urban and natural conditions. They also show that they are able to analyze water treatment problems in a limited time and apply the necessary procedures for the protection of public health, as well as to develop process optimization and solutions for municipal wastewater treatment considering technical and legal regulations.

The tasks often require own formulations, in some cases, multiple choice answers, the focus however being on short calculation tasks. In the exam, limited aids such as lecture handouts and personal notes are allowed. Not allowed are text books, internet and communication among themselves and with third parties.

#### Repeat Examination:

Next semester

**(Recommended) Prerequisites:**

Siedlungswasserwirtschaft Grundmodul (BGU38016)

Siedlungswasserwirtschaft Projektkurs (BGU38020)

**Content:**

1. Water supply resources and source protection; Character of raw water qualities
2. Regulatory and technical requirements
3. Processes to abstract, treat, store and distribute water for potable supply
4. Structure and organization of public water supply
5. Operation and maintenance of water treatment facilities
6. Character of wastewater, in particular municipal wastewater
7. Regulatory requirements and discharge standards
8. Approaches to treat municipal wastewater/resource recovery facilities
9. Fundamentals of biotechnology and microbial reactions/processes
10. Biological treatment processes
  - a. Activated sludge processes (aerobic, anaerobic)
  - b. Sequencing Batch Reactor (SBR) Technology
  - c. Biofilm reactors
11. Disinfection (chlorine-based; UV irradiation)
12. Biosolids stabilization and energy recovery from waste streams

**Intended Learning Outcomes:**

After completion of this module course the students are able to:

- conceptually know and understand drinking water and wastewater treatment facilities and processes
- they will be able to apply the knowledge to select proper siting for drinking water facilities considering constraints within the urban and natural environment
- to analyze critical control points and evaluate the appropriate treatment unit processes to protect public health
- to create optimized treatment processes based on regulatory and technical requirements
- to know and understand the need and feasibility of wastewater treatment, with special emphasis on treatment of municipal wastewater
- to apply individual unit processes and operations to remove problematic constituents from wastewater using biological processes for organic and inorganic constituents as well as pathogens
- to analyze resource management related to wastewater treatment
- to conceptually create designs for conventional processes for wastewater treatment and evaluate their performance.

**Teaching and Learning Methods:**

The module consists of a lecture with integrated exercises. In the lecture, the technical and legal requirements for water and wastewater treatment as well as the theoretical principles of mechanical and biological treatment methods are presented by means of presentations. Furthermore, holistic concepts for water and wastewater treatment are presented. On the basis of

the lecture, the methods for water and wastewater treatment are worked into voluntary problem-solving exercises during class exercises and via the Moodle platform.

**Media:**

Powerpoint presentations; Exercises in class and as voluntary homework via classworks during the lecture and via Moodle

**Reading List:**

Crittenden et al. (2012), Water Treatment Principles and Design , 3rd edition, John Wiley & Sons, New York, 2012

Edzwald, J. (2011), Water Quality & Treatment , 6th edition, McGraw Hill, New York, 2011

McGraw-Hill; 4th edition (2003). Wastewater Engineering Treatment and Reuse

Fourth Edition by Metcalf & Eddy, Inc.

Gujer, Willi (2007). Siedlungswasserwirtschaft. Springer, 3., bearb. Aufl.

**Responsible for Module:**

Prof. Dr.-Ing. Jörg Drewes (jdrewes@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Water and Wastewater Treatment Engineering (Vorlesung mit integrierten Übungen, 4 SWS)

Drewes J [L], Drewes J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38024: Advanced Water Treatment and Anaerobic Processes | Weitergehende Wasserbehandlung und Anaerobtechnik

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a 120-minute written closed book test consisting of theoretical questions and calculation tasks.

The aim of the theoretical questions is to demonstrate that students understand approaches to typical tasks in fields such as water treatment and anaerobic technology, water reuse and energy recovery from urban residual streams. The students show that they are able to analyse and evaluate different treatment methods and select process approaches (including process concepts for anaerobic technology and energy recovery) for realistic problems. On the basis of practical tasks, they show that they are able to design sites for water reuse as well as estimate the related hazard potential and develop process optimisations using technical guidelines and legal requirements.

Students have to analyse water engineering tasks in a limited time, find and implement suitable solutions. The answers sometimes require own formulations, the focus being however on short calculation tasks.

Except for a non-programmable pocket calculator, no aids are allowed for the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering (or equivalent courses on master's level)

#### Content:

- Introduction, regulatory and technical requirements of water reuse and seawater desalination

- Treatment trains to facilitate non-potable reuse
- Treatment trains leading to drinking water augmentation
- Advanced water treatment leading to water reuse: Ozone und Advanced Oxidation Processes (AOPs), Adsorption onto activated carbon (PAC, GAC), High-pressure membrane processes (Nanofiltration, reverse osmosis)
- Risk assessment and critical control points
- Process trains for seawater desalination; regulatory requirement
- Basics of anaerobic digestion
- Modeling of anaerobic digestion processes
- Treatment of sewage sludge (Introduction, agricultural use and incineration, recovery of phosphorous)
- Pre-treatment for enhanced digestibility
- Co-digestion
- Deammonification and CANDO
- Power to gas

#### **Intended Learning Outcomes:**

After completing the module students are able to understand and remember the concepts and processes for advanced water treatment; analyse siting constraints within the urban and natural environment; they can evaluate process requirements and conceptually create design water reclamation and reuse facilities as well as seawater desalination plants. Based on the understanding of regulatory and technical requirements, students will be able to analyze critical control points to create schemes for treatment processes optimizations.

In addition, the students will be able to remember the basic process concepts of anaerobic processes and energy recovery, analyze and evaluate the advantages and disadvantages of the different methods for the specific application and develop simple approaches to calculate and dimension treatment schemes.

#### **Teaching and Learning Methods:**

The module consists of two lectures. Theoretical basics as well as current guidelines are presented during the lectures. Approaches for the application of the different treatment methods are discussed in the lectures through practical examples. Exemplary calculations for the design of treatment methods and the assessment of risks are also carried out. In the subsequent exercise, the students apply the presented methods on further tasks. The self-study is supported by the provision of advanced technical literature in Moodle.

#### **Media:**

Powerpoint presentations, black board, Exercises in class and as voluntary homework via Moodle

#### **Reading List:**

Will be provided via Moodle

#### **Responsible for Module:**

Jörg Drewes (j.drewes@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Advanced Water Treatment Engineering and Reuse (Vorlesung, 2 SWS)

Drewes J [L], Drewes J

Anaerobtechnik und Energierückgewinnung (Vorlesung, 2 SWS)

Koch K [L], Koch K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Elective Modules | Wahlmodule

### Module Description

#### **BGU38011: Wastewater Conveyance Systems and Stormwater Management | Bewirtschaftung von Kanalnetzen und Regenwassermanagement**

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The written exam (120 min) consists of general questions and calculations.

In the written exam students demonstrate by answering questions the theoretical knowledge of components of sewer systems and rainwater management. By doing calculations they show that they are able to create calculation tasks in sewer systems and rainwater management topics. The answers require own formulations but also multiple choice tests are involved. Focus are calculations.

The use of a calculator and the formulary, given during the lectures, are allowed in the written exam.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Siedlungswasserwirtschaft Grundmodul (BGU38016)

Siedlungswasserwirtschaft Projektkurs (BGU38020)

#### **Content:**

Fundamental regulations for sewer systems are learned in this course. Construction and operation of sewer systems are analysed as well as failure in construction and operation. Cost calculation is a big part of the operation of sewer systems. Operating experiences are transferred.

Central and decentral rainwater management are content of the lecture. Laws that are used for building and planning rainwater storage, rainwater reclamation and reuse are discussed. Pollutants in rainwater runoffs and rainwater treatment are shown as well.

**Intended Learning Outcomes:**

After completion of the module, students are able to evaluate the planning and operation of sewer systems, based on simple cost calculations. They can assess holistic concepts to handle rainwater and know treatment processes and options for utilization. After completion of the module students are furthermore able to assess storm water quality and quantity and to propose strategies for rainwater management.

Students can also plan and conduct measures for construction and maintenance of canals and related systems. They can estimate costs for maintenance and are able to conduct simple cost comparison.

**Teaching and Learning Methods:**

The theoretical principles are taught in lectures using presentations as well as the blackboard. To understand the basics taught in lectures, calculation exercises are carried out during the lectures in accordance with the German regulations.

A small excursion to the city drainage systems gives on-site insight into the actual facilities.

**Media:**

Beamer, Powerpoint and board, field trip

**Reading List:**

DIN 1986-100: Entwässerungsanlagen für Gebäude und Grundstücke, 2008

DWA-A 118: Hydraulische Bemessung und Nachweis von Entwässerungssystemen, 2006

DWA –A 117: Bemessung von Regenrückhalteräumen, 2013

DWA-A 166: Bauwerke zur zentralen Regenwasserbehandlung und -rückhaltung, 2013

DWA-A 138: Planung, Bau und Betrieb von Anlagen zur Versickerung von Niederschlagswasser, 2005

DWA-M 153: Handlungsempfehlungen zum Umgang mit Regenwasser, 2007

DWA-M 158: Bauwerke der Kanalisation – Beispiele, 2006

DWA-M 159: Kriterien zur Materialauswahl für Abwasserleitungen und –kanäle, 2005

DWA A-105: Hinweise für die Wahl des Entwässerungsverfahrens (Mischverfahren/ Trennverfahren)

DWA-A 531: Starkregen in Abhängigkeit von Wiederkehrzeit und Dauer, 2012

**Responsible for Module:**

Apl. Prof. Dr. Helmreich, Brigitte; b.helmreich@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Bewirtschaftung von Kanalnetzen und Regenwassermanagement (Vorlesung mit integrierten Übungen, 4 SWS)

Helmreich B [L], Helmreich B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU38021: Industrial Wastewater Treatment and Reuse | Industrieabwasserreinigung und Wiederverwendung

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The proof of performance is made in the form of a 60-minute written exam with questions on the fundamental understanding as well as small calculation tasks.

The aim of the written exam is the proof that the basic principles and approaches in the fields of industrial wastewater treatment, water reclamation and reuse, as well as integrated environmental protection measures are understood in industrial operation and different methods approaches can be applied comparatively. Problems need to be analyzed and based on learning outcomes acquired in the courses of the module students need to find and implement solutions in limited time.

The answers require partly own formulations, partly ticking given single or multiple answers and short calculation tasks. For the exam no aids are permitted except for a non-programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Participation in "Sanitary Engineering and Water Quality Basic Module" (BGU38016) and "Water and Wastewater Treatment Engineering" (BGU38014) is required. General requirement is basic knowledge of wastewater treatment is efficient.

#### Content:

Contents of the lecture are the definition of water flows and complexity of effluents of various industries with mostly organic or inorganic ingredients. Legal regulations, process and production integrated environmental protection, end-of-pipe technology also belong to the content of the lecture as well as mechanical, chemical and physical treatment methods, aerobic and anaerobic biological treatment (special procedures). Using examples from different industries both integrated

environmental protection measures, as well as wastewater treatment and wastewater reuse are described.

**Intended Learning Outcomes:**

Students are able to evaluate possibilities of integrated environmental protection measures and wastewater treatment processes and wastewater reuse in the industry. They know characteristics of industrial wastewaters compared to domestic wastewater. Students know which legal regulations for the treatment of industrial wastewater in Germany are necessary. Students are able to estimate combined methods (physical/ biological) for the elimination of toxic elements.

**Teaching and Learning Methods:**

The theoretical background and the current guidelines are presented in lectures. By means of example from industrial facilities and examples in the lecture, possible solutions are discussed and exemplified calculations are performed. On the basis of lecture notes in Moodle learned content can be repeated and internalized. The self-study is supported by the provision of further literature in Moodle.

**Media:**

Beamer, blackboard, power-point slides

**Reading List:**

Power-point slides as pdf in moodle

**Responsible for Module:**

Helmreich, Brigitte

**Courses (Type of course, Weekly hours per semester), Instructor:**

Industrieabwasserreinigung und Wiederverwendung (Vorlesung, 2 SWS)

Helmreich B [L], Helmreich B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38022T2: Practical Aspects of Engineered Natural Treatment Systems | Praktische Aspekte Natürlicher Aufbereitungsverfahren

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Students' ability to conduct laboratory analysis and to evaluate results will be assessed in a joint group report as coursework without grade.

The proof of performance will be made in the form of a 60-minute written exam. The aim of the written exam is to prove understanding of basics and mechanisms of natural treatment systems and the ability to plan and design simple systems based on natural treatment processes by using existing guidelines. The answers mostly require partly own formulations, but also ticking given single or multiple answers and short calculations will be required. For the exam no aids are permitted except for a non-programmable calculator. The examiner will provide additional documents if needed for the exam.

The written exam also determines the final grade of the entire module.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering

#### Content:

This module deals with processes and application of engineered natural treatment systems. Major abiotic and microbial transformation processes will be discussed in general and with respect to different applications including vertical flow and horizontal flow constructed wetlands, bank filtration and different applications of managed aquifer recharge technology. In addition, students will learn basics on enzymatic processes and reactions. The module also comprises engineering aspects for design and operation of engineered natural treatment systems as well as contents from ongoing research towards optimization of these systems and combinations with other treatment processes

for water reuse. Practical aspects of the laboratory include an evaluation of treatment efficiency and microbial/enzymatic characterization of natural treatment processes.

**Intended Learning Outcomes:**

Upon successful completion of this module, students are able

- To describe major mechanisms and key parameters for contaminant removal in natural treatment systems
- To explain microbial and enzymatic processes and their dynamics in natural treatment systems
- To outline design of wastewater treatment with constructed wetlands for small communities based on local parameters
- To characterize methods and applications of bank filtration and groundwater recharge and discuss their potential for application in future water concepts
- To assess the performance of natural treatment systems by means of analytical methods and
- To analyze and discuss enzymatic processes and enzyme activity in natural systems.

**Teaching and Learning Methods:**

The module comprises a seminar with following laboratory. Main contents will be taught as a lecture with integrated discussions. Furthermore, students will work in groups to develop solutions for selected case studies within the seminar. Additional field trips will help to further understand learned contents. During the laboratory students will learn to assess processes using analytical procedures. In addition, they learn new approaches to improve understanding of analyzed processes.

**Media:**

Presentation, group work, experiment

**Reading List:**

Will be announced at the beginning of the course.

**Responsible for Module:**

Dr.-Ing. Uwe Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**

Natürliche Aufbereitungsverfahren (Seminar, 2 SWS)

Hübner U [L], Hübner U

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38027: Field Trips Urban Water Systems Engineering | Exkursionen Siedlungswasserwirtschaft

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam requirement is a written report about a selected facility, which is jointly prepared in small groups. Through this a critical assessment report, students show that they are capable of a deeper discussion of the topic and are also able to apply knowledge acquired in lectures upon a selected technical facility.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Water and Wastewater Treatment Engineering
- Anaerobic Processes and Energy Recovery
- Advanced Water Treatment Engineering and Reuse

#### Content:

The main focus of this elective module is to convey practical knowledge. Selected facilities of urban water systems engineering and management will be visited. The program is specified at the beginning of each semester in order to respond to up-to-date developments (for example, a visit to a water treatment plant under construction) and to provide a wide range of insights to the students. Visits may include the following technical systems:

- Water catchment areas, water treatment facilities
- Sewer systems, rainwater retention basins
- Municipal and industrial wastewater treatment plants; water reclamation and reuse facilities
- Stormwater management systems in urban areas
- Biogas plants and composting facilities
- Plants for the thermal recycling of sewage sludge
- Landfill leachate treatment facilities

**Intended Learning Outcomes:**

After the successful participation, the students are able to:

- understand the basic process concepts of selected facilities,
- analyze the different methods for the specific urban water system application,
- and to transfer knowledge to other similar systems.

**Teaching and Learning Methods:**

The successful transfer of knowledge in this case requires active participation of the students. By an intensive examination of the information provided and interacting with local experts and operational staff during the visit, additional knowledge can be gained that is beyond the theory acquired during lecture sessions. By visiting selected facilities, the knowledge acquired from lectures focusing on urban water systems engineering is illustrated by practical examples enhancing students' understanding of complex interactions of process engineering, biology and chemistry. For the preparation of the final reports, the expertise of the responsible lecturer can be utilized.

**Media:**

Field trip

**Reading List:**

keine

**Responsible for Module:**

Dr.-Ing. Konrad Koch, k.koch@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38028: Water Resource Recovery Process Simulation and Design | Prozesssimulation und Design von Kläranlagen

Version of module description: Gültig ab summerterm 2017

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>67   | <b>Contact Hours:</b><br>23          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Achievement of the course learning outcomes will be assessed through two voluntary mid-term assignments, and a graded final project.

For the final project, students will develop a model of a real-world wastewater treatment system using the dynamic wastewater treatment simulation software package BioWin, and evaluate various options for a major upgrade of the treatment system to meet new discharge regulations. The students' abilities to apply the wastewater treatment theory covered in lectures in the development of treatment system models, perform simulations, analyze and present simulation results in graphical and tabular form, and formulate engineering design recommendations will be evaluated. The final project will also be used to assess students' understanding of, and ability to explain, the role of key water resource recovery processes in achieving treatment goals and their ability to describe the design approaches and operational control parameters for these processes. The first voluntary mid-term assignment will also assess students' abilities to model wastewater treatment processes using BioWin; however, the modeling assignment will be more constrained than for the final project, and the emphasis will be on assessing students' progress in mastering the BioWin platform. Completion of the model development and simulations and preparation of the written report is designed to take 8 to 10 hours.

For the second voluntary assignment, students will work individually or in pairs to develop a modeling tutorial. The students will present background information on the model element being taught and the wastewater treatment process being modeled and will lead their fellow students through the completion of the tutorial. Successful completion of each voluntary course assignment will result in an improvement of 0.3 in the module grade.

#### Repeat Examination:

**(Recommended) Prerequisites:**

Water and Wastewater Treatment Engineering

**Content:**

The course will provide a critical link between the wastewater treatment theory covered in Water and Wastewater Treatment Engineering and the engineering practice of water resource recovery facility process design. Key concepts related to the design and operation of key treatment processes (including activated sludge, nitrification, biological nutrient removal, trickling filters, anaerobic digestion, and/or gravity and membrane solids separation) will be reviewed. The course will also introduce students to a dynamic modeling software package (BioWin). Students will learn how to apply engineering theory to build models of water resource recovery facilities and simulate their performance using BioWin.

**Intended Learning Outcomes:**

Upon successful completion of this module, students will be able to:

- Given the treatment and resource recovery goals for a wastewater flow, develop an appropriate treatment flow scheme and explain the role of each treatment process in achieving the treatment goals.
- Describe the key design approaches and operational control parameters for key water resource recovery processes.
- Use the dynamic simulation software package BioWin to construct models of water resource recovery facilities and perform steady-state and dynamic simulations of their performance for constant and dynamic, respectively, wastewater inputs.
- Generate data tables and graphs using BioWin and effectively describe model development and results in report form.
- Analyze simulation results and formulate engineering design recommendations based on these analyses.

**Teaching and Learning Methods:**

Lectures and active, in-class problem-solving exercises will be used to review key treatment design principles to ensure that all students have the necessary background needed to build meaningful models and perform useful simulations. Hands-on tutorials will be used to teach students how to build models of wastewater treatment systems and perform simulations using BioWin, a dynamic wastewater process simulator that is widely used by engineering consulting firms. Students will also work individually or in pairs to develop tutorials covering additional model functions to facilitate peer learning. Students will complete wastewater treatment and design assignments and a project to develop and facilitate assessment of their modeling abilities and creative problem-solving skills.

**Media:**

Modeling and tutorials using PC

**Reading List:**

Wastewater Engineering, Treatment and Reuse, Fifth Edition, Metcalf and Eddy, Inc. (M&E) by G. Tchobanoglous, F. L. Burton, and H. D. Stensel, ISBN-13: 978-0-07-340118-8



**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Prof. Jennifer Becker

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU38034: Design and Operation of Conventional and Natural Water and Wastewater Treatment Systems | Planung und Betrieb konventioneller und natürlicher Verfahren zur Wasser- und Abwasserbehandlung**

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The Examination will consist of a 120 minute written exam.

The aim of the written exam is to prove that students understand fundamentals, tools and guidelines for the design and construction of municipal wastewater treatment plants as well as basics and mechanisms of natural treatment systems and are able to reproduce and apply them in a compressed form. In addition, students demonstrate their ability to plan and design simple treatment processes and systems based on existing guidelines and design instructions.

The answers mostly require own formulations, but also ticking given single or multiple answers and short calculations will be required. For the exam no aids are permitted except for a non-programmable calculator. The examiner will provide additional documents if needed for the exam.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Water and Wastewater Treatment Engineering

#### **Content:**

- Basic processes for wastewater treatment, procedures for planning (work phases) , announcement and operation
- Major abiotic and microbial transformation processes in natural treatment systems
- Vertical flow and horizontal flow constructed wetlands, bank filtration and different applications of managed aquifer recharge technology
- Conceptual design, dimensioning, design, positioning and location of plants, basics of construction, elements of a wastewater treatment plant

- Design and operation of engineered natural treatment systems
- Supplementary elements, side operating systems, analytics and monitoring
- Plant optimization, plant renovation, Special issues

**Intended Learning Outcomes:**

Upon successful completion of this module, students are able

- to name and classify systems for treatment of wastewater as well as necessary auxiliary installations of a wastewater treatment plant,
- To describe major mechanisms and key parameters for contaminant removal and their dynamics in natural treatment systems,
- to develop design and plan for a sewage treatment plant according to the principles applied to the work phases 1 to 9 of HOAI,
- To outline design of wastewater treatment with constructed wetlands for small communities based on local parameters,
- To describe technical regulations and legal requirements and optimize existing wastewater treatment plants based on these requirements,
- To characterize methods and applications of bank filtration and groundwater recharge and discuss their potential for application in future water concepts

**Teaching and Learning Methods:**

The module will be taught in two seminar series where major content will be taught in form of short lectures with integrated discussion. Furthermore, students will work in groups to develop solutions for selected case studies within the seminars. Additional field trips will help to further understand learned contents.

**Media:**

Presentation, discussions, exercises, group work

**Reading List:**

Will be announced at the beginning of the course.

**Responsible for Module:**

Uwe Hübner (u.huebner@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Planung und Betrieb von Kläranlagen (Seminar, 2 SWS)

Hübner U [L], Böhm B, Hübner U

Natürliche Aufbereitungsverfahren (Seminar, 2 SWS)

Hübner U [L], Hübner U

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38035: Advanced Water Treatment - Unit Operations Laboratory | Weitergehende Wasserbehandlung - Praktikum

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The expected learning outcome is verified in the form of laboratory assignments. The assignments will be based on oral briefings held by students to prepare for experiments and analyses (20%), participation in laboratory (40%) and a final report (40%). During Q&A prior to experiments, students demonstrate that they know principles and objectives of unit processes and can list and explain key parameters for application in wastewater. By active participation in lab experiments they show their ability to perform tests and follow lab procedures according to the manuscript. The grade for the report will be divided into an individual part for teams of 2 students evaluating one experiment (80%) and the joint group report discussing all experiments (20%). Students demonstrate with the report that they can critically evaluate results from their own experiments.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering; Advanced Water Treatment and Reuse

#### Content:

Development of design criteria and performance assessment of different advanced water treatment processes for application in wastewater:

- Ozonation/Advanced oxidation processes (AOPs)
- High-pressure membrane treatment
- Adsorption onto activated carbon (PAC/GAC)
- Biofiltration
- Analysis of trace organic chemicals by HPLC-UV

**Intended Learning Outcomes:**

Upon completion of this lab course students will be able to

- Describe major targets and design principles of ozonation, advanced oxidation, high-pressure membrane processes, adsorption onto activated carbon and biofiltration for advanced water treatment,
- List key parameters for advanced treatment processes and discuss their relevance for application in wastewater,
- Apply simple tests to assess the efficiency of different advanced treatment processes for wastewater treatment and
- Explain analytical determination of individual trace organic chemicals by HPLC and evaluate resulting HPLC chromatograms,
- Critically evaluate test results with respect to the effects of operational parameters and water quality on the efficiency of advanced treatment processes.

**Teaching and Learning Methods:**

The module consists of a laboratory course. This hands-on laboratory course is designed as an add-on in support of the lecture series "Advanced Water Treatment and Reuse". In different experiments, students learn to perform short process assessment, to analyze chemical concentration by HPLC and to evaluate data. In order to learn and practice the processes in the laboratory, the students prepare themselves reading the course manual and then work in the laboratory in small teams of 2-6 students under the guidance of a supervisor. Results from experiments will be discussed with the tutor.

**Media:**

Short ppt presentations, peer instruction, laboratory work

**Reading List:**

Laboratory manual

**Responsible for Module:**

Uwe Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**

Weitergehende Wasserbehandlung - Praktikum (Praktikum, 4 SWS)

Hübner U [L], Hübner U

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38036: Fundamentals of Hydrochemistry | Grundlagen der Wasserchemie

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The written exam (120 min) consists of general questions and calculations. With the exam students demonstrate that they understand basics and specific interactions of water and hydrochemistry. Their theoretical knowledge of hydrochemistry should enable them to predict precipitation / dissolution of minerals, analyse redox reactions and corrosion processes, predict partitioning and transformation of organic pollutants in the environment and are able to develop treatment concepts for specific water contaminants.

The exam is a mix of open questions requiring own descriptions, single choice tests and chemical calculations. The use of a calculator and the formulary from the course is allowed in the written exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge of inorganic and organic chemistry from the 2nd and 3rd semester BSc. environmental engineering are necessary to follow lectures.

#### Content:

In the lecture the scope of hydrochemistry, water cycle, chemical thermodynamics and reactions will be discussed. Acids and bases, dissolved carbon dioxide and the carbonate equilibria are presented. Precipitation and dissolution, redox and corrosion processes are content of the course as well as transformation mechanisms of organic chemicals. Furthermore, natural and anthropogenic substances, their partitioning and transformation and their influences on the chemical composition of natural waters are shown.

**Intended Learning Outcomes:**

After completion of the module, the students are able to describe the behavior of organic and inorganic water constituents (geogenic or anthropogenic) as well as their interactions and reactions under different environmental conditions and during their treatment in technical systems. They can predict precipitation / dilution, apply redox reactions and analyze corrosion processes. They are further able to evaluate partitioning and transformation of geogenic and anthropogenic water constituents and to develop specific methods for their treatment.

**Teaching and Learning Methods:**

Presentations during the lectures provide the theoretical basis on water chemistry. Understanding of chemical calculations will be supported in small exercises based on relevant practical applications.

**Media:**

Beamer, board

**Reading List:**

- Stumm, W., Morgan, J.J.: Aquatic Chemistry. John Wiley & Sons, 1996, 3rd ed., ISBN: 0-471-51184-6
- Grohmann, A.N., Jekel, M., Grohmann, A., Szewzyk, R., Szewzyk, U.: Wasser. De Gruyter Verlag, 2011, ISBN 978-3-11-021308-9
- Reemtsma, T., Jekel, M.: Organic Pollutants in the Water Cycle. Wiley-VCH, Weinheim, ISBN-10: 3-527-31297-8

**Responsible for Module:**

Brigitte Helmreich

**Courses (Type of course, Weekly hours per semester), Instructor:**

Angewandte Wasserchemie (Vorlesung, 2 SWS)

Bakkour R, Elsner M ( Popp C )

Hydrochemistry (Vorlesung, 2 SWS)

Helmreich B [L], Helmreich B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38037: Aquatic Microbiology | Aquatische Mikrobiologie

Version of module description: Gültig ab winterterm 2020/21

|                       |                             |                                  |                                      |
|-----------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b>  | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3 | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination will take the form of a laboratory assignment consisting of a report (70%) and a final presentation (30%). In the clearly structured report of the practical course (introduction, methods, results, discussion) the students show that they have understood the essential contents, methods and results for the identification and quantification of microorganisms in aquatic systems and can summarize them accordingly. In the presentation, the basic knowledge of the function of microorganisms in the environment as well as in technical systems is tested.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Hydrochemistry laboratory

#### Content:

Microorganisms of natural and technical aquatic systems are studied. The students acquire knowledge about typical microorganisms in the individual aquatic ecosystems and their relevance.

The knowledge to be acquired/deepened includes  
an overview of the microbiology of water bodies

- Microbes in aquatic ecosystems
- Spatial and temporal distribution
- Aquatic biofilms and planktonic communities

Microbial diversity

- Typical representatives of the different water ecosystems
- The role of viruses and protists
- Microbial services and cycles



- Microbial degradation of pollutants

#### Methods

- Recording of cell numbers and cell condition
- Cultivation vs. molecular methods
- Capturing diversity of microbial communities
- Detection of pathogens and antibiotic resistance

#### Intended Learning Outcomes:

After successful participation in the module, students are able to

- estimate the abundance of microorganisms in the environment and in technical systems
- describe the functions of microorganisms
- quantify micro-organisms from aquatic systems and
- identify micro-organisms from aquatic systems

#### Teaching and Learning Methods:

Essential learning contents on the function and occurrence of microorganisms in aquatic systems are taught in the form of short lectures and supplemented by independent literature studies. The detection and identification of aquatic microorganisms in the laboratory is illustrated with practical experiments. In small groups, selected laboratory protocols of microbiology are learned and applied.

#### Media:

Presentations, script, publications

#### Reading List:

Nduka Okafor, Environmental Microbiology of Aquatic and Waste Systems, Springer 2011; Phillip Doherty/Sigee. Freshwater Microbiology: Biodiversity and Dynamic Interaction of Microorganisms in the Aquatic Environment. Koros. 2017.

#### Responsible for Module:

Christian Wurzbacher (c.wurzbacher@tum.de)

#### Courses (Type of course, Weekly hours per semester), Instructor:

Aquatische Mikrobiologie (Praktikum, 2 SWS)

Wurzbacher C [L], Wurzbacher C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV180004: Modelling of Water Quality in Aquatic Systems | Modellierung der Wassergüte in aquatischen Systemen**

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination is a 60-minute written test. The aim of the written test is to verify that the basic approaches for modeling of aquatic systems were understood. These problems must be analyzed and based on learning outcomes acquired in the course of the module, find and implement solutions in limited time.

The answers require partly own formulations, partly graphical visualization. The focus is on short calculation and modeling tasks. For the exam no aids are permitted except for a non-programmable calculator.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basics of aquatic systems as well as in mathematical, physical and chemical knowledge are required.

#### **Content:**

1. INTRODUCTION. Aquatic systems and their types: natural and man-made aquatic systems; water and wastewater treatment units. Common features of aquatic systems. The concept of mathematical modeling of aquatic systems: the general hydrodynamic and mass balance equations.

2. THEORY OF REACTORS. Reactions kinetics - order of reaction. Reactor vessels. Theoretical types of flow: Plug Flow vs. Continuous Stirred Tank Reactors. Hydraulic retention time and the concept of Flow through Curve. Reactors in series. Reactor analysis.

3. SIMPLE APPROACHES FOR MODELING OF BIOGAS PRODUCTION. Using Excel for implementing simple models. Useful tools. First steps in modeling.

4. AQUASIM. General introduction to the software. Application exercise for a river simple system for nitrification and biomass decay. Calibration of model parameters. Critical discussion of measurements and model outputs.

**Intended Learning Outcomes:**

After completion of the module students can describe the approaches for simple models, set-up and analyze mass and energy balances, are able to create simple simulations with own modifications.

**Teaching and Learning Methods:**

.In the lecture theoretical principles are first taught using both presentations and black board. In following exercises with commercial (Excel) or specialized software (AquaSIM), the students apply the lessons learned on similar tasks and thereby internalize the approach. The results are discussed and analyzed afterwards.

**Media:**

Board, beamer, computer

**Reading List:**

Chapra S. C. (2008) Surface Water-Quality Modeling. Waveland Press Inc, Long Grove.

Maniak, U. (1997) Hydrologie und Wasserwirtschaft - Eine Einführung für Ingenieure. Springer Verlag, Heidelberg.

Reichert, P. (1998) AQUASIM 2.0 – User Manual. Swiss Federal Institute for Environmental Science and Technology (EAWAG), Dübendorf.

Wichern, M. (2010): Mathematische Simulation biochemischer Prozesse in der Siedlungswasserwirtschaft, Oldenbourg Industrieverlag, München.

**Responsible for Module:**

Dr.-Ing. Konrad Koch, k.koch@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modelling of aquatic systems (Modellierung aquatischer Systeme) (Vorlesung, 2 SWS)

Koch K [L], Koch K

Modelling of aquatic systems (Vorlesung, 2 SWS)

Koch K [L], Koch K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV180051: Hydrochemistry Lab | Hydrochemie Praktikum

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The expected learning outcome is verified in the form of laboratory assignments. The assignments consists of an oral exam to prepare the experiments (20%) in the form of a survey on the experimental design and operation, the laboratory work which consists of 20 experiments (60%), and a final report about the experiments (20%). By answering questions at the beginning of the experiments, the students show that they are sufficiently prepared for the experiments and. During the experiments, they show that they are able to apply the analytical methods according to the guidelines. The students show through the report that they know and understand laboratory methods for the determination of wastewater and drinking water parameters.

Eine Prüfungswiederholung ist nicht möglich, da die Leistung eine Teilnahme am Praktikum erfordert und die Plätze für das Praktikum beschränkt sind.

An exam retake can not be offered since it would imply another participation at the course with limited participants.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering (BGU38014), Advanced Water Treatment Engineering and Reuse (BGU38010/BGU38024), Hydrochemistry (BV 180006)

#### Content:

During the course the determination of the relevant analytical parameters of wastewater is learned by the students: COD, BOD, TOC, nitrate, ammonium. Furthermore the settleability of sludge as well as the sludge volume index are analysed by the students. Phosphate is identified. Respiration measurement of activated sludge as well as batch tests for nitrification are done by the students. Determination of relevant parameters for drinking water quality are a big part of the course: pH value, conductivity, marble dissolution test, water hardness, sodium and potassium

by atomabsorption spectrometry, chloride and sulfate by ion chromatography and kinetic iron oxidation.

**Intended Learning Outcomes:**

Upon successful completion of this course, students are able to determine and discuss water parameters in the laboratory, which are relevant for the design of wastewater treatment plants and waterworks. In addition, they can perform batch tests to assess the nitrification activity in activated sludge.

**Teaching and Learning Methods:**

The module consists of one exercise. During six experimental (full) days in the laboratory exercise students learn to analyze different parameters and perform various tests. In order to learn and practice the processes in the laboratory, the students prepare themselves reading the course manual and then work in the laboratory in teams of 2 students under the guidance of a supervisor. Results from analyzed parameters will be discussed in small groups of 6 students with the tutor.

**Media:**

Experiments in the laboratory

**Reading List:**

Manual „Hydrochemistry Laboratory“

**Responsible for Module:**

Apl. Prof. Dr. Brigitte Helmreich (b.helmreich@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrochemistry laboratory (Übung, 4 SWS)

Knoop O [L], Helmreich B, Hübner U, Knoop O, Petz S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV380004: Microbiology of Groundwater Ecosystems | Mikrobiologie von Grundwasserökosystemen**

Version of module description: Gültig ab summerterm 2011

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

written exam

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basics in ecology and Microbiology

#### **Content:**

The course consists of an

-introduction to Groundwater ecosystems

" what makes them different

" porous vs. karst and fissured systems

" Organismic repertoire

" Energetic constraints

" Heterotrophy vs. Autotrophy

" Case study: lithoautotrophic ecosystems in caves (Frassassi, Movile)

-Microbiological basics - FAQs

" How is a bacterial cell composed

" How to convert biomass in cells assimilation efficiencies

" Growth in the subsurface How fast do microbes reproduce

" Transport and Migration rates - How fast can a bacterium swim

-Microbes in groundwater and aquifers

" The limits for life

- " Spatial and temporal distribution
- " Sessile vs. attached
- " Are there biofilms in aquifers?
- " Dormant vs. active
- " Case study: Distribution of bacteria in a pristine (Anif) and a contaminated (Flingern) aquifers

-Viruses in the subsurface

- " What is a virus
- " Natural and pathogenic viruses
- " Lytic vs. lysogenic viruses
- " The viral shunt component of the microbial food web
- " Viral control of microbial activities
- " Case study: The granitic aquifer of the ASPÖ hard rock lab in Sweden

-Microbial diversity in the subsurface

- " Conceptual frameworks
- " Methods to study microbial diversity
- " Driving forces
- " Case study: Selected hydrocarbon contaminated aquifers

-Microbial activity in the subsurface

- " Aerobic vs. anaerobic mode of living
- " Important anaerobic respirations
- " Thermodynamic constraints
- " Most important redox processes
- " Case study: The tar oil-contaminated aquifer in Flingern

-Trophic interactions in aquifers

- " Syntrophy, symbioses
- " Microbial food webs and trophic channels
- " Protozoa, Fungi
- " Groundwater Fauna
- " Case study: The karst systems of the Rax and Schnealpe

-Groundwater ecosystem services

- " Water purification and drinking water production
- " Biodegradation
- " Water balancing and GW dependent ecosystems
- " Microbes as bioindicators
- " Development of ecological sound assessment schemes
- " Case study: The UBA project

-Groundwater contamination and microbial biodegradation

- " Priority contaminants in groundwater

- " Future contaminants
- " Groundwater legislation and EU-WFD
- " What is degradable and what not?
- " Case study: Aromatic hydrocarbons
  
- Characterization of microbial communities
  - " Molecular community analyses
  - " Identification of key-players
  - " Determination of in situ activities
  - " Labelling as a tool to identify key-processes
  
- Life in the deep subsurface
  - " Is there life independent from land surface?
  - " Radiolysis, geogenic electron donors
  - " Microbiology of deep geothermal waters
  
- (Bio)Remediation strategies for contaminated groundwater
  - " Injection of electron acceptors / donors
  - " Bioaugmentation
  - " Reactive barriers
  - " Monitoring of natural attenuation

This module can be seen as an advanced class building up partly on the lectures on 'Basics of Ecology' and 'Microbiology'.

#### **Intended Learning Outcomes:**

Students are able to estimate the microbiology and biogeochemistry of groundwater ecosystems, which is essential for the understanding of subsurface processes including formation of geological units as well as the transport and degradation of contaminants.

#### **Teaching and Learning Methods:**

Teaching methods will include, besides the classical presentation mode, interactive work ( e.g. discussion individual tasks and working on exercises in small groups). Students will be actively integrated in the teaching and learning process applying state of the art educational tools. Applied exercises related to daily life problems and short movies will complement the lectures.

#### **Media:**

Beamer, handouts

#### **Reading List:**

Chappelle, F.H. (2000) Ground-Water Microbiology and Geochemistry, Wiley; Griebler, C. & Mösslacher, F. (2003) Grundwasser-Ökologie, UTB-Facultas, Wien. Specific literature will be distributed in form of scientific articles.



**Responsible for Module:**

Brigitte Helmreich (b.helmreich@bv.tu-muenchen.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CH3121: Analytical and Organic Environmental Chemistry | Analytische und Organische Umweltchemie

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>105  | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcome of the module will be assessed through a written exam of 90 minutes.

The exam aims to assess the students' learning outcome based on their (i) understanding of chemical/physical/biological processes that determine fate of organic chemicals, (ii) ability to apply the relevant processes to particular a environmental/analytical task, (iii) and ability to evaluate appropriate analytical techniques to investigate behavior of organic chemicals.

#### Repeat Examination:

Next semester / End of Semester

#### (Recommended) Prerequisites:

Analytische Chemie I, Instrumentelle Analytik

Fortgeschrittene analytische Verfahren mit Übungen

Physikalische Chemie 1 (CH0655)

Organische Chemie 2 (CH0939)

#### Content:

The module consists of two parts, namely lectures (120 minutes) and exercises (60 minutes). The lectures are intended to familiarize the students with the fundamental concepts of environmental processes and analytical techniques used for investigating the fate of organic chemicals. Whereas, the exercises enable the students to apply the fundamental concepts to solve practical problems.

Lectures will include:

- Occurrence and sources of organic chemicals and appropriate sampling strategies.
- Enrichment and purification techniques (in air, water, organic phases, soil), analytical techniques based on sorption and poly parameter linear free energy relationships.

- Reaction chemistry and analytical techniques to decipher mechanisms (Transformation kinetics, hydrolysis, Hammett relationships, oxidation & reduction, isotope effects, concentration dynamics).
- Photo-stability of organic compounds (direct & indirect photolysis, photo-produced reactive intermediates).
- Analytical tools for decision-making on remediation, and environmental risk assessment.

Exercises will include, among others:

- Databases on properties and fate of organic chemicals.
- Construction of ppLFER for a given dataset.
- Estimation of chemical fate in porous media.
- Calculation of breakthrough volumes.
- Estimation of degradation rates of organic contaminants through direct photolysis.
- Prediction of distribution of chemicals in different phases (i.e. air, water, solid).
- Designing a field sampling campaign.
- Selection of analytical tools for demonstration of degradation.

### **Intended Learning Outcomes:**

Upon completion of the module, students will be able to:

- Understand different chemical, physical, and biological processes that influence fate of organic chemicals in the environment as well as in the analytical process chain.
- Apply fundamental concepts to predict environmental fate of contaminants such as persistence, transport, and bioaccumulation.
- Evaluate sampling strategies and analytical tools for investigating organic contaminants in a given environmental compartment.
- Differentiate pathways through which contaminants degrade in the environment.

### **Teaching and Learning Methods:**

The fundamental concepts will be presented in the lecture part by demonstrating a relevant environmental analytical problem followed by elaborating on the fundamental concepts necessary to solve it along with practical examples. The lectures will make use of power point slides and blackboard. An interactive exchange between the lecturer and the students will be promoted using a web-based live feedback system that enable all students to vote for multiple-choice quizzes that will be presented during the lectures followed by a discussion of the votes outcome.

Practical exercises will be distributed every week for topics that are linked to the fundamental concepts taught during the lecture. The assigned tasks will be presented by the students in the dedicated sessions, as small subgroups, using slides and/or blackboard. Discussion and feedback on the contents of each session will take place between the tutor and the students.

### **Media:**

Slides, blackboard, videos, tweedback

### **Reading List:**

Environmental Organic Chemistry (Schwarzenbach, Imboden, Gschwend, 2017)

**Responsible for Module:**

Elsner, Martin; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Case Studies in Analytical and Environmental Chemistry (CH3121) (Vorlesung mit integrierten Übungen, 3 SWS)

Bakkour R, Elsner M ( Popp C )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### MW1969: Desalination | Desalination [Desal]

Version of module description: Gültig ab summerterm 2013

|                                         |                             |                                  |                                      |
|-----------------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5                   | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The theoretical knowledge gained in the lecture is to be practically applied in exercise lessons by means of case studies. The exercises course also includes a laboratory course in which students carry out experiments with lab-scale desalination plants.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Physics, Thermodynamics and Heat and Mass Transfer.

#### Content:

Potable water is one of the most valuable resources we have on our earth. The "blue gold" is essential for any life. Potable water resources are limited and water scarcity is a big challenge in many parts of the world already today and will become even more urgent in the future. Water desalination is one of the main technological answers to this challenge. Today, 80 Million Cubicmeter per day of Desalination Capacity is installed worldwide, showing exponential growth. This lecture wants to provide students with both basic theoretical and practical tools to be able to cope with engineering solutions to overcome the future lack of potable water. The focus will be on the thermodynamic and chemical properties of seawater, the wide range of different desalination technologies with a major on distillation and membrane processes, renewable energy and transient power supply in desalination, large and small scale applications and finally also on desalination-driven environmental aspects.

#### Intended Learning Outcomes:

Having successfully passed the Desalination lecture the young engineers are able to understand, design and optimize desalination plants on their own. Furthermore they are sensitized for future technological challenges in desalination e.g. transient power supply for membrane processes.

A deep understanding of the advantages and disadvantages of different desalination principles empower them not only to make viable decisions during plant design and construction but also to use their knowledge to further develop existing ideas. The students are prepared for solving engineering problems about potable water issues with a strong focus on desalination.

**Teaching and Learning Methods:**

In the lecture, the subject matter is explained in an oral presentation. The exercises include both presentation and experimental investigations of the students themselves. The exercises put the main focus on deepening the understanding of the theoretical aspects taught in the lecture. Difficulties will be explained in detail and problems of understanding will be solved. The exercises are not obligatory but highly recommended also in view of the exam.

**Media:**

Oral presentations, Tablet-PC support, lab-scale desalination plants (solar stills) in laboratory courses, exercises as preparation for the final exam.

**Reading List:**

Lecture notes and transcript incl. references.

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Tutorial Desalination (Übung, 1 SWS)

Polifke W [L], Spinnler M

Desalination (Vorlesung, 2 SWS)

Polifke W [L], Spinnler M ( McClure J )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Field of Study 2: Water Resources Management | Vertiefung 2: Water Resources Management

### Required Modules | Pflichtmodule

#### Module Description

### BGU54009: Flood Risk and Flood Management | Hochwasserrisiko und Hochwassermanagement [FRM]

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a 120-minute written test. Only permitted aid is non-programmable calculator. The necessary mathematical formulas are given on the test sheets.

In the written exam, the students demonstrate that they can explain the concepts of hydrological floodwater modeling and flood risk management, taking into account the legal framework as well as social boundary conditions. Through practical tasks on typical flood events, they demonstrate that they can apply quantitative methods for damage and risk assessment, as well as perform risk-based assessment and sensitivity analysis of the effectiveness of flood protection measures.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamentals of hydrology (e.g. Hydrology Basic Module (BGU54006), bachelor program Umweltingenieurwesen, TUM),

Fundamentals of probability theory and risk analysis (e.g. Environmental Monitoring and Risk Management (BGU54007 or BGU54025), bachelor program Umweltingenieurwesen, TUM),

Fundamentals of programming in Matlab

### **Content:**

First the general motivation of flood risk management (FRM), the social and political framework of FRM as well as tools and models for the hydrologic/hydraulic modelling of the flood events are provided. Also different strategies and measures of technical and decentral flood protection are included. In the second part of the course, quantitative methods for analyzing the flood damage and flood risk and for risk-based evaluation/optimization of the flood protection measures. The accompanying exercises will provide brief summary of programming in MATLAB and the students will learn how to implement the theory explained in the lectures on simple but realistic examples using Matlab and the water balance model LARSIM, which is used wide spread in Middle Europe for flood forecasts.

#### **Lecture**

- Safety, security, and risk
- The risk management cycle
- Qualitative and quantitative methods for flood risk assessment
- Planning of flood protection measures: determination of design values
- Flood frequency statistic base on gauged data
- Contents and significance of the EU directive on the assessment and management of flood risks
- Overview of technical and decentral flood protection measures
- Failure of flood protection measures
- Flood hazard scenarios
- Risk and risk acceptance: Communication of risks and legal aspects.

#### **Exercise**

- LARSIM: Understanding and dealing with the water balance model LARSIM in reasons of flood forecast and river basin modelling.

#### **Quantitative risk assessment: lecture and exercise**

- Decision-making, risk acceptance, optimization of mitigation measures
- Flood damage assessment
- Risk quantification
- Uncertainty quantification, sensitivity analysis
- Issues of long-term planning: non-stationarity, adaptability

### **Intended Learning Outcomes:**

After completing the module, the students are able to:

- Understand the basic concepts of flood risk management as well as its legal and social framework,
- to apply methods for the hydrological modeling of flood events;
- to apply quantitative methods for general risk assessment and damage assessment as well as for specific flood risks
- evaluate and select the effectiveness of flood protection measures.
- to apply sensitivity analysis
- to use the MATLAB programming in the specific field of flood risk management.



- to use the hydrological water balance model LARSIM to solve questions of flood prediction.
- to structure and implement the theoretical and mathematical concepts in calculation algorithms.

### **Teaching and Learning Methods:**

The module consists of lectures with integrated exercises.

The theoretical basics are presented through a lecture series. The students are encouraged to study the recommended literature and deepen their knowledge in certain topics. Computer exercises based on practical problems are solved by the students. They sharpen their technical skills in dealing with MATLAB and LARSIM. The exercises are individual or group work. Voluntary homework tasks, which are to be worked in groups,

### **Media:**

Power-Point-Presentation,  
Blackboard,  
Computer lab

### **Reading List:**

The documents and resources listed below are some examples for your interest:

Flood Manager E-Learning (TU Hamburg-Harburg): <http://daad.wb.tu-harburg.de/homepage/>

Merz, B., J. Hall, M. Disse, and A. Schumann. "Fluvial Flood Risk Management in a Changing World." *Natural Hazards and Earth System Science* 10, no. 3 (March 16, 2010): 509–527. doi:10.5194/nhess-10-509-2010.

Rogger, M., Kohl, B., Pirkel, H., Viglione, A., Komma, J., Kirnbauer, R., Merz, R., Blöschl, G., 2012. Runoff models and flood frequency statistics for design flood estimation in Austria – Do they tell a consistent story? *J. Hydrol.* 456–457, 30–43.^

Bründl, M., Romang, H.E., Bischof, N., Rheinberger, C.M., 2009. The risk concept and its application in natural hazard risk management in Switzerland. *Nat. Hazards Earth Syst. Sci.* 9, 801–813.

Pianosi, F., Wagener, T., Rougier, J., Freer, J., Hall, J., 2014. Sensitivity Analysis of Environmental Models: A Systematic Review with Practical Workflow, in: *Vulnerability, Uncertainty, and Risk*. American Society of Civil Engineers, pp. 290–299.

### **Responsible for Module:**

Prof. Dr.-Ing. Markus Disse ([markus.disse@tum.de](mailto:markus.disse@tum.de))

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Flood Risk and Flood Management (Vorlesung mit integrierten Übungen, 4 SWS)

Disse M [L], Broich K, Disse M ( Broich K, Gerner A ), Gerner A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54011: Integrated Water Resources Management | Integriertes Wasserressourcen Management [IWRM]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a written, closed book test of 120 min duration. The exam will consist of open questions, multiple choice questions and mainly exercises which will require short computations.

Through short and precise answers to theoretical questions, the students demonstrate that they are able to understand the principles of integrated and sustainable water management; different institutional roles in the water management sector in several countries, methods and tools of integrated water resources planning and management as well as analyze and evaluate water related decision problems. The practical part is based on exercises mainly associated to the analysis and application of a preliminary IWRM plan, to the application of simulation tools for a river basin, and to the application of the most common optimization methods in water resources management problems. This will allow verifying the understanding by the students concerning the application of basic IWRM concepts, their ability to differentiate between a range of river basin management tools and models as well as apply those concepts (e.g. linear and nonlinear optimization tools) for the solution of problems within a given period of time.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge of hydology

#### Content:

1. Introduction
  - Introducing Water Resources Management
  - The Overall Problem and Main Challenges

- Need for optimized water resources management
- System Components, Planning Scales and Sustainability
- Planning and Management
- Integrated Water Resources Management
- Definition of IWRM
- IWRM History and Principles
- The enabling environment
- The institutional roles
- Management instruments
- Water Management at River Basin Scale
- IWRM and capacity development
- 2. Decision Support Systems (Short Introduction)
- 3. Water Resources Planning and Management River Basin Management Overview
  - Framework for water resources planning and management
  - Modelling of Water Resources Systems
  - River Basin Planning and Management Models
  - Modelling Methods: Simulation, Optimization, Multi Criteria Analysis
- 4. Optimisation
  - Short Introduction to Economics for Engineers
  - Introduction to optimization
  - Calculusbased methods
  - Linear optimization
  - Dynamic optimization
  - Multiobjective optimization
- 5. Multi Criteria Analysis
- 6. Uncertainty Analysis
  - Time Series Generation
  - Sequent peak algorithm and Reservoir Management

#### **Intended Learning Outcomes:**

At the end of the module, students are able to:

- understand the principles of integrated and sustainable water management,
- understand different institutional roles in several countries,
- apply linear and nonlinear optimization tools,
- analyze and evaluate water related decision problems,
- differentiate between a range of river basin management tools and models.
- understand and apply methods and software tools of integrated water resources planning and management .

#### **Teaching and Learning Methods:**

The module consists in a lecture with integrated exercises.

The teaching concept of this module is based on the fact that different study goals will be achieved using different approaches. While theoretical concepts and mathematical equations require an indepth explanation, which is provided during the lectures, the understanding of a model

requires hands-on, practical learning, which will be provided during the integrated exercises and the homework. During the lectures, the students will understand the theory behind the models. They are going to apply those models in the integrated exercises and the homework. Whenever necessary, a complementary theoretical background of the models is provided in the exercises in order to enhance the understanding of the students. In this way, at the end of the module, they will be able to create their own model from one side, of a river basin and to make an analysis of various water allocation and water resources management strategies and from the other side, to build an optimization problem and to solve it for the most important water resources problems (optimal water allocation, storage capacity – yield, reservoirs operation and groundwater supply).

Students have to bring their own laptop to the computer exercises.

**Media:**

Power-Point-Presentation, blackboard, software

**Reading List:**

- Water Resources System Planning and Management (Daniel P. Loucks)
- Global Water Partnership Technical Advisory Committee (TAC) Background paper on Integrated Water Resources Management
- <http://www.gwp.org/en/The-Challenge/What-is-IWRM/Dublin-Rio-Principles/>
- Bonn 2011 Conference proceedings The Water, Energy and Food Security Nexus, Solutions for the Green Economy
- United Nations World Water Assessment Programme

**Responsible for Module:**

Prof. Dr.-Ing Markus Disse [markus.disse@tum.de](mailto:markus.disse@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Integrated Water Resources Management (Vorlesung mit integrierten Übungen, 4 SWS)

Disse M [L], Chiogna G, Disse M, Gerner A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Elective Modules | Wahlmodule

### Module Description

#### **BGU38011: Wastewater Conveyance Systems and Stormwater Management | Bewirtschaftung von Kanalnetzen und Regenwassermanagement**

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The written exam (120 min) consists of general questions and calculations.

In the written exam students demonstrate by answering questions the theoretical knowledge of components of sewer systems and rainwater management. By doing calculations they show that they are able to create calculation tasks in sewer systems and rainwater management topics. The answers require own formulations but also multiple choice tests are involved. Focus are calculations.

The use of a calculator and the formulary, given during the lectures, are allowed in the written exam.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Siedlungswasserwirtschaft Grundmodul (BGU38016)

Siedlungswasserwirtschaft Projektkurs (BGU38020)

#### **Content:**

Fundamental regulations for sewer systems are learned in this course. Construction and operation of sewer systems are analysed as well as failure in construction and operation. Cost calculation is a big part of the operation of sewer systems. Operating experiences are transferred. Central and decentral rainwater management are content of the lecture. Laws that are used for building and planning rainwater storage, rainwater reclamation and reuse are discussed. Pollutants in rainwater runoffs and rainwater treatment are shown as well.

**Intended Learning Outcomes:**

After completion of the module, students are able to evaluate the planning and operation of sewer systems, based on simple cost calculations. They can assess holistic concepts to handle rainwater and know treatment processes and options for utilization. After completion of the module students are furthermore able to assess storm water quality and quantity and to propose strategies for rainwater management.

Students can also plan and conduct measures for construction and maintenance of canals and related systems. They can estimate costs for maintenance and are able to conduct simple cost comparison.

**Teaching and Learning Methods:**

The theoretical principles are taught in lectures using presentations as well as the blackboard. To understand the basics taught in lectures, calculation exercises are carried out during the lectures in accordance with the German regulations.

A small excursion to the city drainage systems gives on-site insight into the actual facilities.

**Media:**

Beamer, Powerpoint and board, field trip

**Reading List:**

DIN 1986-100: Entwässerungsanlagen für Gebäude und Grundstücke, 2008

DWA-A 118: Hydraulische Bemessung und Nachweis von Entwässerungssystemen, 2006

DWA –A 117: Bemessung von Regenrückhalteräumen, 2013

DWA-A 166: Bauwerke zur zentralen Regenwasserbehandlung und -rückhaltung, 2013

DWA-A 138: Planung, Bau und Betrieb von Anlagen zur Versickerung von Niederschlagswasser, 2005

DWA-M 153: Handlungsempfehlungen zum Umgang mit Regenwasser, 2007

DWA-M 158: Bauwerke der Kanalisation – Beispiele, 2006

DWA-M 159: Kriterien zur Materialauswahl für Abwasserleitungen und –kanäle, 2005

DWA A-105: Hinweise für die Wahl des Entwässerungsverfahrens (Mischverfahren/ Trennverfahren)

DWA-A 531: Starkregen in Abhängigkeit von Wiederkehrzeit und Dauer, 2012

**Responsible for Module:**

Apl. Prof. Dr. Helmreich, Brigitte; b.helmreich@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Bewirtschaftung von Kanalnetzen und Regenwassermanagement (Vorlesung mit integrierten Übungen, 4 SWS)

Helmreich B [L], Helmreich B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46036: Water Resources and Hydropower | Wasserwirtschaft und Wasserkraft [WRHP]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written exam (120 minutes, open book, allowed tools: notes, print medias (books, printed slides...), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

The students will prove that they are able to apply modelling techniques in water management and to design the volumes and water levels of a reservoir.

Furthermore, they prove that they can design a water power station in concept and dimensioning as well as the state-of-the-art technologies for energy storage.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Bachelor's level knowledge in hydraulic engineering, e.g.

- "Basic Module Hydraulic and Water Resources Engineering"
- "Supplementary Module Hydraulic and Water Resources Engineering"

#### Content:

The module provides in-depth knowledge of principles, methods and technologies for calculation and management of water resources, as well as the sustainable generation of energy from hydropower.

- precipitation, runoff and runoff coefficient
- rainfall-runoff modelling

- flood routing
  - flood statistics
  - reservoir capacity
  - storage plans and operation schemes
  - flood retention
- 
- types of hydro power stations, specific requirements of large and small hydro power
  - elements of hydro power installations
  - hydro turbines: turbine types, application ranges
  - stream turbines: fundamentals, turbine types, application range
  - energy conversion in hydro turbines - physical fundamentals
  - planning of hydro power stations: hydrological surveys, layout, power plan
  - needs and requirements for energy storage
  - fundamental options for power storage
  - properties of storage technologies, pros and cons, application ranges, potential, development state, project examples
  - pumped storage plants: fundamentals, electromechanical equipment, new approaches

### **Intended Learning Outcomes:**

After successful participation in the module, students will be able

- to apply important and mainly used modelling techniques and calculation methods of water management
- to assess their application areas and limitations
- to design a reservoir under the aspects of hydrology and water resources management
- to describe, identify and assess established and newly proposed technologies of hydropower and energy storage
- to explain and assess the physical foundations of the energy conversion as well as the fundamental approach in planning hydropower projects
- to evaluate hydropower project plans and to perform planning themselves.

### **Teaching and Learning Methods:**

- lecture style
- practical examples
- coordinated moodle tests (voluntary)

### **Media:**

- PowerPoint presentations with film sequences and computer animations
- blackboard exercises
- moodle tests (voluntary)
- lecture notes in moodle

### **Reading List:**

see lecture notes



**Responsible for Module:**

Dr.-Ing. Richard Huber (richard.huber@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Sustainable Water Resources Management (Vorlesung, 2 SWS)

Huber R, Scherbaum S

Hydro Power and Energy Storage (Vorlesung, 2 SWS)

Reisenbüchler M [L], Reisenbüchler M, De Vos L, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54008T2: Hydrological and Environmental River Basin Modelling | Hydrologische und ökologische Flussgebietsmodellierung [HERBM]

Version of module description: Gültig ab winterterm 2013/14

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a 90 minute written exam and additional course work.

In the written exam, the students show that they have achieved the learning outcomes under pressure of time (knowing and understanding constituents of transport processes /cycles of matter and their numerical modelling). The exam consists of 1/3 theoretical questions and 2/3 calculations. Allowed tool is a non-programmable calculator.

The course work serves to assess the students' competence to apply an eco-hydrologic model and to process the simulation output data. Further the ability to analyze and present the results in a comprehensive way is tested.

During the exercises the students start the course work (e.g. model setup, methods to evaluate modelling results) and receive support by student tutors and the lecturing tutor. After they have received the final question for the course work, the students can continue working on it during the remaining exercises and during self-study hours in groups of 4 persons and have to prepare and hand in a written report (approx. 20 pages).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basics of hydrology and GIS

#### Content:

Different components of an eco-hydrological model and their interactions will be explained and their respective calculation methods will be presented:

- Climate data and snow
- Evapotranspiration
- Infiltration and soil water

- Surface runoff
- Groundwater
- Streamflow

Additionally, modelling of plant growth and associated water as well as nutrient demands are presented. Water quality aspects and the interplay with issues of land use and management practices are also brought up.

- Nutrients and nutrient transport
- Erosion
- Plant growth and management practices

Eco-hydrological modelling will be taught based on a practical example in the computer lab:

- Model setup in SWAT
- Carrying out simulations
- Evaluation of model results: data post-processing
- Evaluation of model results: interpretation of results and diagnosis
- Manual calibration

### **Intended Learning Outcomes:**

At the end of the module, the students are able to:

- understand how environmental processes (i.e. concerning the water cycle) are modelled in numerical eco-hydrological software model like SWAT.
- understand different methods for the calculation of single components of eco-hydrological cycles and their interplay.
- use an eco-hydrological model
- process the model results for evaluation
- identify different influencing factors on the model quality
- assess the meaningfulness of model results and
- present them in a comprehensive fashion in a final assessment report.

### **Teaching and Learning Methods:**

The module consists of a lecture and an exercise.

Lecture (talk, presentation, group work): The lecture provides the historical, mathematical and empirical basics for various modelling approaches to the different model components (e.g.: Green and Ampt in comparison with SCS-CN method to model infiltration). The underlying assumptions, characteristics (Which kind of behavior, observed in nature do we want to mimic? For instance the seasonal and sinusoidal oscillation of soil temperature and damping with depth), data requirements and limits of application are discussed. The lecture therefore aims at the first two study goals.

Exercises (talk, presentation, individual and group work, case study): A detailed investigation of single model components as it is done in the lecture is hardly possible for the practical application of the software. The interplay of model components (climate, soil, aquifers, runoff, sediments, plant growth) is often complex and non-linear over time. The application of a software model, the understanding of the interplay of its many components as well as the assessment of the results is taught and learned with hands-on exercises – computer lab and course work.

**Media:**

Lecture; PowerPoint presentations, black board, scientific papers,

Exercise: Script, Software: SWAT, ArcSWAT, SWATPlot, Excel, R, SWATCup, Technical Manuals

**Reading List:**

Neitsch, S., J. Arnold, J. Kiniry, and J. Williams (2011). Soil and water assessment tool- theoretical documentation version 2009. Report, Grassland, Soil and Water Research Laboratory - Agricultural Research Service, Blackland Research Center - Texas AgriLife Research.

Winchell, M., R. Srinivasan, M. diLuzio, and J. Arnold (2007). ArcSWAT Interface for SWAT2005 - Users Guide. [http://www.geology.wmich.edu/sultan/5350/Labs/ArcSWAT\\_](http://www.geology.wmich.edu/sultan/5350/Labs/ArcSWAT_Documentation.pdf)

Documentation.pdf: Blackland Research Center and Grassland, Soil and Water Research Laboratory (USDA Agricultural Research Service)

Arnold, J., J. Kiniry, R. Srinivasan, J. Williams, E. Haney, and S. Neitsch (2011). Soil and Water Assessment Tool- Input/Output File Documentation Version 2009. <http://swat.tamu.edu/media/19754/swat-io-2009.pdf>: Grassland, Soil and Water Research Laboratory

Agricultural Research Service, Blackland Research Center Texas AgriLife Research.

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse ([markus.disse@tum.de](mailto:markus.disse@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrological and Environmental River Basin Modelling (Vorlesung, 2 SWS)

Disse M, Tuo Y

Hydrological and Environmental River Basin Modelling - Exercise (Übung, 2 SWS)

Disse M, Tuo Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54013T2: Seminar in Rainfall-Runoff Modelling | Seminar Niederschlags-Abfluss Modellierung [SRRM]

Version of module description: Gültig ab winterterm 2014/15

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Total duration: 45 min.

- Presentation and discussion (30 min.)
- Oral exam (15 min.)

#### Repeat Examination:

#### (Recommended) Prerequisites:

Hydrological fundamentals,  
e.g. Grundmodul Hydrologie (Bachelor Umweltingenieurwesen, TUM)

#### Content:

The course contents are based on the book Rainfall-Runoff Modelling: "The Primer" by Keith Beven from Lancaster University:

The book provides a primer for the novice and detailed descriptions of techniques for more advanced practitioners. [ & ] It gives a comprehensive summary of available techniques based on established practices and recent research, [ offering ] a thorough and accessible overview of the area.

- 1.Runoff Processes and the Modelling Process
- 2.Evolution of Rainfall-Runoff Models
- 3.Data for Rainfall-Runoff Modelling
- 4.Predicting Hydrographs Using Models Based on Data

5. Predicting Hydrographs Using Distributed Models Based on Process Descriptions
6. Hydrological Similarity, Distribution Functions and Semi-Distributed Rainfall Runoff Models
7. Parameter Estimation and Predictive Uncertainty
8. Models for Changing Risk
9. Next Generation Hydrological Models
10. Predictions in Ungauged Basins
11. Water Sources and Residence Times in Catchments
12. Hypotheses, Measurements and Models of Everywhere

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### **Intended Learning Outcomes:**

At the end of the module, students are able to:

- Know the theory of different types of rainfall-runoff models.
- Understand the concepts that underlie different modelling approaches.
- Evaluate models and critically assess the assumptions made.

Furthermore the students should learn to:

- Present a topic, as well as to facilitate and lead a discussion about it.

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### **Teaching and Learning Methods:**

The module consists of a seminar with an introductory lesson given by the lecturer. The students will form groups of two people and pick a topic they will present in the consecutive lessons. The activities comprise:

- Literature study
- Summarizing and presenting a topic
- Guiding and facilitating a discussion on the presented topic
- Consecutive online tests

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### **Media:**

Powerpoint  
Blackboard

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### **Reading List:**

Beven, K. J. Rainfall-Runoff Modelling: The Primer. 2nd ed. Chichester, West Sussex/; Hoboken, NJ: Wiley-Blackwell, 2012.

AVAILABLE as .pdf download though the TUM library (eaccess login -> search in UB catalogue)

**Responsible for Module:**

Markus Disse (markus.disse@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Seminar in Rainfall-Runoff Modelling (Vorlesung, 2 SWS)

Disse M [L], Tuo Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU54015: Water Management at the Catchment Scale (Field trip to the Adige River Basin) | Wassermanagement auf Einzugsgebietsebene (Exkursion in das Etsch Einzugsgebiet) [WMCS]**

Version of module description: Gültig ab summerterm 2016

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>50   | <b>Contact Hours:</b><br>40          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The students, divided into small groups (max 3 persons), will prepare a short report (15-20 pages) about one of the 4 topics related to the field trip: management of hydropower production in Alpine catchments, climate change and the Alpine cryosphere, contaminant loads in rivers, salt water intrusion. Each group will prepare a presentation of the report (20 minutes) during the field trip at the location where that particular issue is relevant. The evaluation of the exam will be based on

- a) the capability of the students to work autonomously during the literature review related to their research topic (group grade 40 %)

- b) the quality of the written report and of the oral presentation (group grade 40%)

- c) oral exam following the oral presentation (single grade 20%) about a specific aspect of the presentation

Beside the technical skills it will be evaluated the quality, the accurateness and the style of the presentation of the results and the team-working capacity.

In this way, it will be possible to evaluate both the performance of the group and the performance of each single component as well. The relative weight of the grade depends on the required workload.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

- Hydrological and Environmental River Basin Modelling
- Integrated Water Resources Management
- Modeling and Management of Groundwater



**Content:**

The field trip will be performed in collaboration with the University of Trento, Department of Civil, Environmental and Mechanical Engineering (Prof. Bellin) and within the FP7 EU Project Globaqua ([www.globaqua-project.eu](http://www.globaqua-project.eu))

The course will focus on the following topics:

- Management of hydropower production in Alpine catchments
- Climate change and the Alpine cryosphere
- Contaminant loads in rivers
- Salt water intrusion

**Intended Learning Outcomes:**

At the end of the module students are able:

- to understand that water management is an issue to be faced at the catchment scale
- to evaluate the effects of climatic forcing on the alpine cryosphere and their effect on water management
- to evaluate the water quality of water bodies at different scales
- to analyze the effects of saltwater intrusion in the Mediterranean region
- to analyze their results in order to prepare an effective oral and written presentation

**Teaching and Learning Methods:**

The course will be offered as a field trip of 5 days. In this way, the student will understand through a direct experience the main issues related to water management at the basin scale. Furthermore, in order to prepare their report and the oral presentation, the students will understand the relevance of team-working. It will required an extensive literature review of the assigned topic, which will be synthetized with a discussion between the group members.

**Media:**

Introduction in the different issues related to water management at the catchment scale and supervision of the groups

**Reading List:**

- Scientific articles of peer review journals depending on the seminar topic
- The EU water framework directive - integrated river basin management for europe ([http://ec.europa.eu/environment/water/water-framework/index\\_en.html](http://ec.europa.eu/environment/water/water-framework/index_en.html))

**Responsible for Module:**

Dr. Gabriele Chiogna ([gabriele.chiogna@tum.de](mailto:gabriele.chiogna@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Water Management at the Catchment Scale (Field trip to the Adige River Basin) (Seminar, 2 SWS)  
Chiogna G [L], Chiogna G, Disse M

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](#).

## Module Description

### **BGU54019: Numerical Modeling of Water Demand and Supply in Arid Regions | Numerische Modellierung von Wasserbedarf und -Versorgung in ariden Gebieten [OWHM]**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The exam consists of the development of a project (i.e. a numerical model with the software OWHM) to be presented in oral form (20 minutes presentation followed by a discussion). The exam will verify i) how the students understand basic concepts of water demand and supply in arid regions; ii) how the students are able to apply those concepts for the solution of realistic case studies.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Basic Module Hydrology (BSc)

Groundwater modeling (MSc)

#### **Content:**

- Basics of water management in arid regions
- Introduction to MODFLOW-OWHM (One Water Hydrologic Model)
- Specific packages of OWHM and physical description of the processes
- Development of the case study
- Presenting a case study

#### **Intended Learning Outcomes:**

At the end of the module, students are able:

- i) to understand the basic principles behind water management in arid regions.
- ii) to apply a physically based model to manage water resources in arid regions.
- iii) to predict water availability according to specific water management conditions.

The course will provide to the students both the theoretical as well the practical knowledge to use MODFLOW-OWHM to solve water management issues in arid regions, including irrigation. Upon completion of the modelling and management part the students will be able to evaluate different groundwater management strategies, to create flow and transport modeling based on field measurements and to apply them to determine water availability, to understand aquifer parameters and evaluate the sustainability of water management options.

**Teaching and Learning Methods:**

Lectures (Power-Point-Presentation, blackboard), exercises (individual, small groups), homework (modelling exercise).

The teaching philosophy behind this module is based on the evidence that different study goals will be achieved using different approaches. While theoretical concepts and mathematical equations require an in-depth explanation, which is provided during the lectures, the understanding of a model requires hands-on learning, which will be provided during exercises and homework. During the lectures, the student will understand the theory, which is behind the model they are going to use in the exercises and homework. In this way, at the end of the module, they will be able to create their own model for the solution of flow and transport in porous media.

**Media:**

Power-Point-Presentation

Blackboard

**Reading List:**

- Chiang, W.-H., & Kinzelbach, W. (2001). 3D-Groundwater Modeling with PMWIN (With CD-ROM). Springer.

- One water hydrologic flow model: <https://pubs.er.usgs.gov/publication/tm6A51>

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse ([markus.disse@tum.de](mailto:markus.disse@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Numerical modeling of water demand and supply in arid regions (OWHM) (Vorlesung, 2 SWS)

Disse M [L], Disse M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54021: Remote Sensing in Hydrology | Fernerkundung in der Hydrologie [RSH]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination is done via a 90 minute written exam. The exam consists of 2/3 theoretical questions and 1/3 calculations. Allowed tool is a non-programmable calculator. Based on theoretical questions, the students show that they understand the principles of remote sensing in hydrology and can evaluate the different satellite products in terms of quality and can understand how to integrate remote sensing data in hydrological modelling to solve the practical limitations of point-based ground measurements. Based on short calculations the students demonstrate that they understand various mathematical procedures for estimating key hydrological components by the means of remote sensing data.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basics of hydrology, hydrological modelling and GIS

Basics of GIS software ArcGIS or QGIS

Basics of programming in Matlab and/or Python

Ability to literature review and critical thinking of scientific journal papers

#### Content:

Contents for lectures:

In first two theoretical lectures, the fundamentals of hydrology and remote sensing will be explained.

Then in the following theoretical lectures, remote sensing methods for different hydrological components and the applications in case studies will be explained and presented:

- Precipitation
- Vegetation

- Evaporation
- Soil moisture
- Water level and water volume
- Groundwater
- Snow and ice

The application of remote sensing in other environmental studies such as land use and land cover classification, soil erosion and water quality will also be briefly discussed.

#### Contents for exercises in the computer lab

The methods for processing various remote sensing products in different formats will be taught based on a practical example in the computer lab:

- Visualization of satellite data (Landsat, MODIS, Sentinel etc.) and projection in ArcGIS
- Processing satellite precipitation TRMM data and comparison with measurements from WMO stations
- Processing vegetation index products from different satellites
- Processing satellite ET products and surface temperature products
- Processing satellite soil moisture products
- Analysis of satellite altimetry data for water level in lakes and reservoirs
- Analysis of groundwater variation from GRACE satellites
- Analysis of MODIS satellite snow cover products

#### **Intended Learning Outcomes:**

1. At the end of the module, the students are able to understand the principles of remote sensing, and how the satellite products for various hydrological components are generated.
2. Students will be able to process various satellite products in the different data formats using ArcGIS, QGIS and some programming software Matlab and Python.
3. Students will be able to evaluate the satellite products, to identify different influencing factors on the satellite data quality, and how to and how to integrate satellite products to hydrological modelling to solve practical problems.

#### **Teaching and Learning Methods:**

The module consists of a lecture.

Lecture (talk, presentation, group work): The lecture provides the fundamentals of hydrology and remote sensing, mathematical remote sensing calculation methods and data formats for various hydrological components (e.g. precipitation, evaporation, water level), and applications of remote sensing in practical hydrological studies.

Exercises (talk, presentation, individual and group work, case study): Hands-on exercises will be given in the computer lab. A detailed investigation of single hydrological components as it is done in the lecture will be achieved through the practical processing of the satellite products. The application of software and programming and the data evaluation will be taught in more details. During the exercises the students learn the satellite data processing in a more practical hands-on manner. The students are expected to learn how to download and process the satellite data. The processing procedures in ArcGIS and some programming in Matlab and Python will also be taught during the exercises. Students will receive support by student tutors and the lecturing tutor. During

the exercise, some small exercises will be assigned but they will be voluntary and used only for students' self-assessment. In the end, a voluntary report can be also handed in: students can form a group with 2 or maximum 4 members to select a topic (e.g. precipitation, water level) to write a report with an approx. 20 pages.

The lectures and exercises in computer lab will be closely linked to achieve the study goals.

**Media:**

Lecture: PowerPoint presentations, black board, scientific papers,

Exercise: Script, Software: ArcGIS, QGIS, Excel, Matlab, Python, and Technical Manuals.

**Reading List:**

Schultz, G. A., & Engman, E. T. (Eds.). (2000). Remote sensing in hydrology and water management. Springer Science & Business Media.

Campbell, J. B. (2002). Introduction to remote sensing. CRC Press.

Davie, T. (2008). Fundamentals of hydrology. Taylor & Francis.

Gebremichael, M., & Hossain, F. (2010). Satellite rainfall applications for surface hydrology. New York: Springer.

Papers from the following journals: Remote Sensing of Environment, Water Resources Research, Journal of Hydrology, International Journal of Remote Sensing etc.

User manuals for specific satellite products. The manuals will be specified during lectures.

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse (markus.disse@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Remote Sensing in Hydrology (Vorlesung, 4 SWS)

Disse M [L], Tuo Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54024: Uncertainty Quantification in Hydrology | Unsicherheitbestimmung in der Hydrologie [UQH]

*Uncertainty quantification in hydrology*

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The students prepare a comprehensive presentation of 60 minutes about a seminal paper related to uncertainty quantification in hydrology. The evaluation considers the quality of the presentation (clarity of the oral presentation and slides), its structure (comprehensiveness beyond the literature provided by the lecturer), capability of answering questions and clarifying both mathematical and hydrological concepts.

The oral presentation of a hydrological paper demonstrates the understanding of the student about the relevant issue of uncertainty quantification in hydrological parameter estimation and predictions. Moreover, it verifies how well the students can summarize complex mathematical and hydrological concepts and explain them to other students within a given period of time. Through short and precise answers to theoretical oral questions, the students demonstrate that they are able to understand the principles and the methods used for uncertainty quantification in hydrology.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Advanced hydrological knowledge
- Advanced statistical knowledge
- Familiarity with preparation of slides and oral presentations

#### Content:

Each student will receive one scientific publication related to uncertainty quantification in hydrology to be presented during the seminar. The assigned publications could be changed every year according to the most recent and valuable scientific publications. The publications will be chosen among open access journals or journals freely accessible to students from the library.

Topics that will be discussed are:

- Model uncertainty in hydrology
- Parameter uncertainty in hydrology
- Parameter estimation
- Model inversion
- Bayesian inversion
- Latin hypercube method
- Markov Chain Monte Carlo Simulations
- Monte Carlo Simulations
- Estimation of effective model parameters
- Equifinality in hydrological models

### **Intended Learning Outcomes:**

The students at the end of the module will be able to:

- Understand and analyse the theory, the methods and the results presented in a scientific paper focusing on uncertainty quantification in hydrology
- Understand and analyse the methods inherent to uncertainty quantification in hydrology
- Evaluate autonomously the relevant literature necessary for the understating of the assigned paper in the field of uncertainty quantification in hydrology
- Create a presentation to explain an assigned topic in the field of uncertainty quantification in hydrology

### **Teaching and Learning Methods:**

The 13 students participating to the seminar will be guided by the lecturer in the oral presentation of a scientific paper. The presentations must be prepared in electronic form by the students following the instructions provided by the lecturer. This teaching method will allow the students to achieve the four learning outcomes described above.

An open discussion involving also the other participants will be moderated by the lecturer after each presentation. This teaching method will allow the students to achieve the first three learning outcomes described above. It is required that each student will participate to the discussion taking place after each student's seminar.

### **Media:**

Powerpoint-Präsentation, Tafelanschrieb, digitale Vorlagen

### **Reading List:**

The assigned publications could be changed every year according to the most recent and valuable scientific publications.

Example of papers that could be used in the seminar are:



Mattis, S. A., Butler, T. D., Dawson, C. N., Estep, D., & Vesselinov, V. V. (2015). Parameter estimation and prediction for groundwater contamination based on measure theory. *Water Resources Research*, 51(9), 7608-7629.

Kitanidis, P. K. (1986). Parameter uncertainty in estimation of spatial functions: Bayesian analysis. *Water resources research*, 22(4), 499-507.

Vrugt, J. A., Ter Braak, C. J., Clark, M. P., Hyman, J. M., & Robinson, B. A. (2008). Treatment of input uncertainty in hydrologic modeling: Doing hydrology backward with Markov chain Monte Carlo simulation. *Water Resources Research*, 44(12).

**Responsible for Module:**

Gabriele Chiogna

**Courses (Type of course, Weekly hours per semester), Instructor:**

Uncertainty quantification in hydrology (Seminar, 2 SWS)

Chiogna G [L], Chiogna G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU54027: Mathematical Methods for Uncertainty Quantification in Hydrology | Mathematische Methoden zur Unsicherheitsquantifizierung in der Hydrologie** [Mathematical methods for uncertainty quantification in hydrology]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>9          | <b>Total Hours:</b><br>270  | <b>Self-study Hours:</b><br>210  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The examination consists in a project work. The project work is designed to test the five learning outcomes (LO) of the module. It will include the following phases: initiation (review of available uncertainty quantification methods as by LO1), problem definition (identification of uncertainties in the hydrological problem as by LO1), role assignment (identifying students' strengths as by LO4), idea generation (selection of appropriate mathematical method as by LO3), criteria development for the selection of the methods (LO2), decision about the strategy to follow to carry on the project (LO4), implementation of the mathematical methods for the hydrological model (LO3), presentation of the results in written (40 pages, including figures, tables, attachments, references) and oral form (20 minutes) (LO5). The project assignment has to be completed within 6 months using an appropriate modeling and programming environment. The project work will include a presentation in order to assess a student's communication competency in presenting scholarly work to an interdisciplinary audience (LO5). The specific components of the project work assignment are: a literature review to show the understanding about the relevance of uncertainty quantification for practical hydrological problems; a part to present how to apply uncertainty quantification methods to simple hydrological problems; a part to explain the rationale behind the selection of the methods (both mathematical and hydrological) in the project; a part to show the capability of the students to apply uncertainty quantification methods to complex hydrological problems; a part dedicated to a critical analysis of both positive and negative results obtained in the project; a part dedicated to the preparation of an effective presentation of the results to an interdisciplinary audience. The project work is a group work of teams of 2 students. Students are expected to demonstrate that they are able to complete the tasks in a team environment by presenting the results together both in written (70% of the grade) and oral (30% of the grade) form. The student's contribution to the group work should be properly indicated in the written and in the oral presentation of the results,

in the hydrological model work and in the code performing the uncertainty quantification of the model.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

Lineare Algebra (MA0004)

Introduction to probability theory and statistics (MA0009)

Introduction to programming (MA0010)

Introduction to hydrology

Hydrological statistics

**Content:**

- Introduction about uncertainties in hydrology
- Rating curves and their uncertainties
- Uncertainties in surface water - groundwater interaction
- Uncertainties in lumped hydrological models
- Sensitivity analysis of hydrological models
- Introduction about uncertainty quantification methods
- Basics of python programming
- Markov Chain Monte Carlo
- Bayesian inversion for linear and non linear models
- Active subspace method
- Presenting uncertainties to an interdisciplinary audience
- Presenting the results on an interdisciplinary project to an interdisciplinary audience

**Intended Learning Outcomes:**

At the end of the module, the students will: LO1. understand the relevance of uncertainty quantification for practical hydrological problems, LO2. be able to apply uncertainty quantification methods to hydrological problems, LO3. be able to critically analyze the results of the applied methods, LO4. be able to effectively work in an interdisciplinary team, LO5. be able to effectively present and communicate the results to an interdisciplinary audience.

**Teaching and Learning Methods:**

The module consists of a project seminar and a lecture with integrated exercises, which is offered as MOOC. Lecture with integrated computational exercises is planned to achieve LO1 and LO2, group work and project seminar to achieve LO3, LO4 and LO5.

A series of lectures (recorded and always available on Moodle) will introduce uncertainty quantification methods and their application in hydrology. This part will cover about 30 h of on line lecture material including practical work (e.g., how to develop python scripts step by step and providing them on line). A team of 2 students (possibly 1 mathematician and 1 environmental

engineer) receives/develops a project in which UQ methods are applied to a real hydrological case. An important aim here is the interdisciplinary component of the group as well as the teamwork. The team of two students is co-supervised by 1 tutor from the chair of numerical mathematics and 1 tutor of the chair of hydrology and river basin management. The group meets each supervisor at least 5 times (a 1 page report of the meeting has to be provided by the students to document the project development). The team provides an interim presentation and a final presentation of the project in both oral and written form. The supervisors will offer to the students a meeting focusing on how to do an effective oral presentation for an interdisciplinary audience."

**Media:**

30 hours of MOOC, relevant scientific publications for the project work

**Reading List:**

- 1 Wagener T. et al. "It takes a community to raise a hydrologist: the Modular Curriculum for Hydrologic Advancement (MOCHA)." Hydrology and Earth System Sciences Discussions 9: 2321–2356.
- 2 Juston, J. et al. ""Smiling in the rain: Seven reasons to be positive about uncertainty in hydrological modelling."" Hydrological Processes 27.7 (2013): 1117-1122."

**Responsible for Module:**

Gabriele Chiogna, Barbara Wohlmuth

**Courses (Type of course, Weekly hours per semester), Instructor:**

Mathematical methods for uncertainty quantification in hydrology MOOC (Vorlesung, 2 SWS)  
Chiogna G [L], Chiogna G, Wohlmuth B

Mathematical methods for uncertainty quantification in hydrology – project seminar (Seminar, 2 SWS)

Wohlmuth B [L], Chiogna G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU57014: Hydrogeodesy: Monitoring surface waters from space | Hydrogeodäsie: Monitoring von Oberflächengewässern aus dem Weltraum**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Type of assessment: written exam

Duration of exam: 90 minutes

Credit requirements will be achieved by a written exam about the competencies conveyed in the lecture. In the exam it is verified that the students understand the scientific challenges of satellite altimetry and its potential for hydrological applications, that they are able to apply observation data of satellite altimetry and evaluate it with respect to its accuracy, and that they understand how the data can be used for the calibration of hydrological models. With the discussion of typical examples and specific problem settings the theoretical understanding and the evaluation skills are examined. Through questions at different levels of difficulty, the written exam allows for an individual verification of the understanding and thus a realistic assessment of the acquired competencies.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### **Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

Prerequisites are fundamentals in mathematics and physics as they are acquired, for example, in the Bachelor programme Environmental Engineering at the TUM. Furthermore, programming skills (Matlab) are required.

**Content:**

1. Introduction: Geodesy, hydrogeodesy, and satellite altimetry
2. Satellite radar altimetry for inland water bodies
3. Exercise: From measured ranges to water levels
4. Inland altimetry databases
5. Exercise: Download and comparison of different inland altimetry products
6. Synergy of satellite altimetry with other satellite- and ground-based techniques (satellite gravity field observations, remote sensing images, gauges, ...)
7. Estimation of volume changes of lakes
8. Exercise: From lake level to volume changes
9. Estimation of river discharge
10. Exercise: From river level to discharge
11. Monitoring of rivers systems
12. Assimilation of altimetry-information into hydrological models
13. Guest Lecture: Hydrological model calibration with satellite data (Prof. Andreas Güntner, GFZ)
14. Alternative space-based observation techniques: Laser and Delay Doppler/SAR altimetry, GNSS-reflectometry
15. A look into the future: NASA's Surface Water & Ocean Topography (SWOT) mission

**Intended Learning Outcomes:**

Upon completion of the lecture, students are able

- to understand the measurement principle of radar altimetry and its potential for hydrological applications at lakes, rivers, and reservoirs.
- to apply satellite altimetry data for the estimation of lake volumes and river discharge within the frame of project and group work,
- to evaluate the quality of altimetry data with respect to other satellite- and ground-based observation and monitoring systems for surface waters,
- to understand the application of satellite data for the calibration of hydrological models.
- to discuss with experts in the field of inland altimetry

**Teaching and Learning Methods:**

The content of the course is taught in a lecture in interaction with the students whereby the learning success is continuously monitored through questions to the students. Mathematical derivations are shown at the black board. Selected literature is discussed with the students. The lecture contains a guest lecture of an expert from the field of hydrological model calibration. Four supervised practical exercises are conducted in the CIP-Pool.

**Media:**

- board content
- presentation slides in electronic Form
- topic-related publications and book chapters

**Reading List:**

- Fu L., Cazenave A.: Satellite Altimetry and Earth Sciences: A Handbook of Techniques and Applications. International Geophysics Series, Vol. 69, San Diego, CA, 2000.
- Vignudelli S., Kostianoy A., Cipollini P., Benveniste J.: Coastal Altimetry, Springer, ISBN: 978-3-642-12796-0, 2011.
- Selected scientific publications will be distributed in the course.

**Responsible for Module:**

Prof. Seitz, Florian

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrogeodesy: Monitoring surface waters from space (Vorlesung, 2 SWS)

Seitz F [L], Dettmering D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66041: Contaminant Transport and Remediation | Transport und Sanierung von Schadstoffen [ContTransRemed]

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

At the end of the module, students participate in a written exam of 120 minutes duration. The exam will focus on the physical and chemical processes underlying contaminant transport and environmental remediation strategies and on the development of related computer models. The exam will verify that the students understand the principles to plan and carry out remediation of contaminated soils and water bodies. Furthermore, it will verify that the students understand basic concepts of environmental chemistry and pollutant transport in the environment and that the students are able to apply those concepts for the solution of problems within a given period of time. The exam will consist of open questions, multiple choice questions and exercises which will require short computations. In knowledge and transfer questions, the students demonstrate both their theoretical knowledge in pollutant hydrogeology and their ability to interpret and evaluate scientific measurement results quantitatively, to develop a prediction for mass dispersion in given exemplary scenarios and to clearly present and visualise the results, e.g. in schematic sketches and cross sections. No auxiliary material is allowed during the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in hydrology, hydrogeology and environmental chemistry (e.g., the MSc module Case studies in technical hydrogeology)

#### Content:

Students acquire the necessary knowledge and skills to quantitatively describe and evaluate the transport of pollutants in groundwater.

- Legal bases for the quality of groundwater and surface water



- Transport of water constituents in saturated and unsaturated environments (dispersion, sorption, degradation)
- Multiphase flow,
- Reactive mixing in surface water bodies
- Colloid transport,
- Transport properties of inorganic and organic contaminants
- General introduction on fate and transport of contaminants in the environment
- Analytical and numerical modeling of reactive solute transport
- Principles of in situ chemical oxidation
- Remediation technology for the unsaturated zone
- Land management

### **Intended Learning Outcomes:**

After participating in the module, the students are able to

- to quantify the spread of pollutants in groundwater and assess the risk of groundwater contaminations in a pollutant-specific way.
- to understand the effects of technical measures (e.g. iron removal, hardening, chlorination) in water treatment on the behaviour of pollutants and to transfer this knowledge to other issues (e.g. mixing of near-surface groundwater with deep groundwater)
- to understand the basic processes controlling commonly applied environmental remediation strategies
- to predict the effectiveness of different remediation strategies

The main objective of the moodle based modeling exercises is to enable students to understand, apply and further develop models to plan, predict and carry on remediation actions.

### **Teaching and Learning Methods:**

The module consists of two lectures. The teaching philosophy behind this module is based on the evidence that different study goals will be achieved using different approaches. The theoretical lectures' contents are presented by the lecturer using both the blackboard and digital slides. The students will get familiar with the subject solving independently relevant practical problems. Additionally, modelling exercises are offered on Moodle (asynchronous), with which the students train their programming skills

### **Media:**

Presentations (beamer/blackboard) , case studies in teams, exercise on e-learning platform

### **Reading List:**

- Kitanidis, P. K. and McCarty, P.L. (2012), Delivery and mixing in the subsurface: Processes and Design Principles for in situ remediation
- Siegrist et al. (2011), In Situ chemical oxidation for groundwater remediation
- Schoor J.L. (1996), Environmental Modeling fate and transport of pollutants in water, air and soil
- Appelo C.A.J, Postma, D. (2006) Geochemistry, Groundwater and Pollution, Balkema, Leiden.
- Clark & Fritz (1997): Environmental Isotopes in Hydrogeology.-398 S. Lewis Publisher.
- Domenico, Schwartz(1998): Physical and chemical hydrogeology.- (Wiley).

Fetter (2001): Applied Hydrogeology.- New Jersey (Prentice-Hall).

Fetter, Boving, Kreamer (1998): Contaminant Hydrogeology, Long Grove (Waveland Press)

Matthess, G. (1994): Die Beschaffenheit des Grundwassers.- 499 S.; Berlin

**Responsible for Module:**

Prof. Dr. Thomas Baumann

**Courses (Type of course, Weekly hours per semester), Instructor:**

Transport von Schadstoffen im Grundwasser (Vorlesung, 2 SWS)

Baumann T

Environmental Remediation Strategies (Vorlesung, 2 SWS)

Chiogna G [L], Chiogna G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV040005: Nature-oriented Care | Naturnahe Bauweisen

Version of module description: Gültig ab winterterm 2011/12

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Written, closed book exam at the end of the semester (60 min.).

The understanding of the fundamentals as well as the capability to evaluate waterway constructions and river development plans is tested in this exam.

The exam consists of question which have to be answered in written form as well as project plans and images where the students have to develop concepts on their own.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Previous attendance of the module "Applied Hydromechanics" (BGU41018T2) is recommended.

#### Content:

- Basic principles: hydrology; morphology; EU framework directive
- watercourses as an eco-system
- properties and categories of watercourses and their meadows
- types of intervention into natural watercourses and their effects
- river development and fundamentals of river development plans
- ecological waterway construction

#### Intended Learning Outcomes:

On successful completion of this module the students are able to:

- explain the basic concepts of hydrology, morphology and river engineering
- demonstrate features and functions of flowing waters and river meadows
- analyse communities and vegetation in the sphere of rivers
- illustrate fundamentals and basic constructive elements of ecological waterway engineering
- evaluate the effects of different kinds of waterway construction

- predict prospective river development according to different criteria

**Teaching and Learning Methods:**

The lecture is structured as a talk accompanied by slides. There the lecturer connects the theory shown in the slides with his practical work experience. Additionally several example projects will be discussed in class. Therefore students are split into small groups, work on the project and present their results in short talks. By this the students capability to analyse and create river development plans is trained.

**Media:**

slides, lecture handouts, drawings of sample projects

**Reading List:**

H. Patt, P. Jürging, W. Kraus, Naturnaher Wasserbau, Springer, Berlin, 2004

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Naturnahe Bauweisen (Vorlesung, 2 SWS)

Brosda J, Neumeier R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV170009: International Water Rights and Politics | Internationales Wasserrecht [GRAMBOW]

Version of module description: Gültig ab winterterm 2020/21

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam in this module is a final written exam (60 min) in which the students have to answer questions in the field of water rights and regulations in an international context.

The comprehension of the lecture contents is also checked by some transfer questions, which are oriented on the presented exemplary areas of application. With the written examination, students demonstrate that they understand the meaning of water for the global development, have knowledge in water rights and regulations in an international context and are able to use sustainable approaches to solve challenges of worldwide water law.

In addition to the final exam, students have the possibility to hold a mid-term presentation of 10-15 min presenting a topic linked to the course content. The presentation will be assessed in a pass/fail mode according to the content of the presentation and the presentation style. By passing the mid-term presentation, students will be awarded a 0.3 bonus on the grade of the final exam. With the mid-term presentation, students demonstrate that they have analyzed a water policy related problem in detail, can assess and evaluate it against the background of international water policy, and can present their summarized results to their fellow students.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bachelor in Civil Engineering or Environmental Engineering

#### Content:

The world water situation is critical. In a first part this is illustrated by showing examples and discussions of international indicators. This should provide the necessary understanding, how policy and law affect this development of problems;

Part two of the course discusses detailed the principles of solutions, which the world has described in the Agenda 21, the approach of Sustainability and the derived Integrated Water Resource Management (IWRM). The basics of good water governance (law and policy) are worked out by introducing the handling of complex structures and check lists like the ten principles of sustainability. This is spiced by enhanced administrative tools and basics of state philosophy. Part three shows and discusses practical solutions: EU- Water Frame Directive; basics of water law at the example of the German WHG and the Bavarian BayWG, Water Policy and Good Governance in practice and the strategy of implementation. The whole lecture includes a discussion of concrete examples from all over the world, delivered by the teacher and the students.

### **Intended Learning Outcomes:**

After completion of the module students will be able to understand the meaning of water for the global development and the multi-dependent system of world environment. They will also understand the important role and principle of sustainability. They will be able to use the sustainable approach for design and construction including balancing the aspects of economy, ecology and social effects and also the usage of integrality (IWRM) and the approaches of efficiency and sufficiency.

They will know the basic lines of good water policy and good governance understand the challenges and principles of worldwide water law.

### **Teaching and Learning Methods:**

In order to complete the module successfully, the knowledge transfer must take place predominantly by practical examples. These examples are provided through a slide presentation. Where possible, also video clips are presented to make contents more clear.

### **Media:**

PowerPoint Presentation and Script

### **Reading List:**

### **Responsible for Module:**

Yannic Fuchs (yannic.fuchs@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Internationale Wasserpolitik und Recht (Vorlesung, 2 SWS)

Grambow M ( Fuchs Y ), Fuchs Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV460012: Rivers as an Ecosystem | Fließgewässer als Lebensraum [KS\_4]

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The written module examination (120 min) consists of two thematic fields, in which the students have to answer simple questions on eco-hydraulics and aquatic ecology without any tools. In addition, the understanding of the learned design methods will be examined by simple transfer tasks, which are based on the presented examples. Further, there will be questions regarding the interdisciplinary understanding (cross-cutting on: hydraulic - eco-hydraulics - aquatic ecology).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Participation in modules:

"Grundmodul Wasserbau und Wasserwirtschaft", module no. BV000030

and

"Ergänzungsmodul Wasserbau und Wasserwirtschaft", module no. BV000048

#### Content:

The module combines the two topics Eco-Hydraulics and Aquatic Ecology, thus comprehensively treating the habitat in watercourses.

Eco-Hydraulics:

- Flora and fauna in and around river basins; meadow vegetation
- Interaction between the river and catchment area
- Continuity: requirements, possible forms, structural realization, regulations

- Design and calculation of fishways and ramps
- Water Framework Directive Water Act

**Aquatic Ecology:**

- Aquatic habitats and aquatic ecosystem types; life support services and threats; gas budget, trophic interactions, nutrients and their dynamics
- lotic ecosystems as dynamic systems: specific features, functions and threats, river continuum concept, bioindication
- lentic ecosystems: ecological classification, specific features, threats,
- case studies: biodiversity, extinction and threats to aquatic ecosystems; conservation biology concepts
- ecotoxicological aspects: endpoints, xenobiotics and endocrine disruptors; human impacts and effects of use on aquatic ecosystems

**Intended Learning Outcomes:**

After attending the module the students are able to:

- understand the basics of ecology and chemistry of waters and the interdisciplinary relationships and specific characteristics of aquatic ecosystems
- apply the design rules to retrieve the river continuity
- analyse the temporal and spatial distribution of biodiversity and productivity in aquatic ecosystems
- estimate and assess effects of human intervention on aquatic ecosystems

**Teaching and Learning Methods:**

The module consists of a lecture. The theoretical course contents are presented by the lecturer and supported by PowerPoint presentations and whiteboard notes. Accompanying exercises and discussions of relevant case studies allow students to participate and to intensify learned contexts. As a part of the lecture, field-specific group work in the classroom is included, in which the students solve simple calculation and discuss case studies independently and present their results afterwards.

**Media:**

Blackboard; PowerPoint presentation; Calculations

**Reading List:**

Schwörbel, Jürgen: Einführung in die Limnologie, Springer Spektrum 2013, ISBN-13: 978-3827421531

Primack, Richard B.: A primer of Conservation Biology, Palgrave Macmillan 2004, ISBN-13: 978-0878937288



Pullin, Andrew S.: Conservation Biology, Cambridge University Press 2002, ISBN-13: 978-0521644822

Helfman, Gene S.: Fish Conservation, Island Press 2007, ISBN-13: 978-1559635967

Postel, Sandra & Richter, Brian: Rivers for Life: Managing water for people and nature, PAPERBACKSHOP UK IMPORT 2003, ISBN-13: 978-1559634441

Di Giulio, Richard T, & Hinton, David E.: The toxicology of fishes, CRC Press, 2008, ISBN 0203647297, 9780203647295

**Responsible for Module:**

Dr.-Ing. Markus Reisenbüchler (markus.reisenbuechler@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Rivers as an Ecosystem (Vorlesung, 4 SWS)

Rüther N [L], Rüther N, Geist J, Reisenbüchler M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Field of Study 3: Hydraulic Engineering | Vertiefung 3: Hydraulic Engineering

### Required Modules | Pflichtmodule

#### Module Description

### BGU46035: Hydraulic Engineering and Hydromorphology | Wasserbauhydraulik und Hydromorphologie [HEHM]

Version of module description: Gültig ab winterterm 2022/23

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written exam (120 minutes, open book, allowed tools: notes, print medias (books, printed slides...), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

Concerning the practical tasks, the students show that they are able

- To precisely explain the design of hydraulic structures (e.g. weirs, dams) as well as the corresponding operating facilities and to design and assess hydraulic structures using calculations in a solution-oriented manner.
- To analyse sediment transport processes and to apply numerical modelling for estimating river morphological change and for designing technical measures in river engineering. A HEC-RAS project is included in the Hydromorphology part and will add additional points to the final exam when successfully completed.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Bachelor's level knowledge in hydraulic engineering, e.g.

- "Basic Module Hydraulic and Water Resources Engineering"
- "Supplementary Module Hydraulic and Water Resources Engineering"

**Content:**

The module provides in-depth knowledge of principles, methods and technologies for calculation and management of hydraulic engineering as well as hydromorphology.

- Fundamentals of hydraulics
- Normative regulations
- functionality, design and construction of hydraulic structures such as inlet structures, transport structures, outlet structures, energy dissipation structures, surge tanks
- danger to hydraulic structures e.g. cavitation, log jam, scour, vortex formations
- Discussion of dynamic loads, river diversions, construction process and safety concepts
- current examples will show actual facilities with their special problems and solution strategies
- typical design questions and calculations in hydraulic engineering
- one-day excursion to typical hydraulic structures in the pre-alpine/alpine area, on-going hydraulic engineering projects or constructions sites
- Introduction into Hydrodynamics
- Properties of sediment
- Sediment transport processes
- River morphology and the influence on sediment transport
- Stable channel design
- River response
- River stabilization
- numerical modelling of river morphology and sedimentation
- Computer Lab: HEC-RAS for Flow and sediment transport analysis

**Intended Learning Outcomes:**

After successful participation in the module, students will be able

- To design hydraulic structures such as weirs, dams and water supply structures in accordance with safety and normative regulations with regard to their hydraulic conditions
- To identify possible dangers to hydraulic structures and options how to avoid them
- To understand and apply modeling techniques and calculations in hydraulic engineering
- To understand and quantify the mechanisms of erosion, transportation and deposition of sediment by flow in the river
- To assess the effects of natural and human interference on river morphodynamics
- To apply hydromorphological numerical modeling and its applications in river work development

**Teaching and Learning Methods:**

- lecture style
- practical examples
- coordinated moodle tests (voluntary)
- small project work using HEC-RAS in groups of two-three students

**Media:**

- PowerPoint presentations with film sequences and computer animations
- blackboard exercises

- moodle tests (voluntary)
- lecture notes in moodle

**Reading List:**

see lecture notes

**Responsible for Module:**

PD Dr.-Ing. habil. Minh Duc Bui (bui@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

River Engineering and Hydromorphology (Vorlesung, 2 SWS)

Bui M

Wasserbauhydraulik (Vorlesung, 2 SWS)

Reisenbüchler M, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46036: Water Resources and Hydropower | Wasserwirtschaft und Wasserkraft [WRHP]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written exam (120 minutes, open book, allowed tools: notes, print medias (books, printed slides...), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

The students will prove that they are able to apply modelling techniques in water management and to design the volumes and water levels of a reservoir.

Furthermore, they prove that they can design a water power station in concept and dimensioning as well as the state-of-the-art technologies for energy storage.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Bachelor's level knowledge in hydraulic engineering, e.g.

- "Basic Module Hydraulic and Water Resources Engineering"
- "Supplementary Module Hydraulic and Water Resources Engineering"

#### Content:

The module provides in-depth knowledge of principles, methods and technologies for calculation and management of water resources, as well as the sustainable generation of energy from hydropower.

- precipitation, runoff and runoff coefficient
- rainfall-runoff modelling

- flood routing
- flood statistics
- reservoir capacity
- storage plans and operation schemes
- flood retention
  
- types of hydro power stations, specific requirements of large and small hydro power
- elements of hydro power installations
- hydro turbines: turbine types, application ranges
- stream turbines: fundamentals, turbine types, application range
- energy conversion in hydro turbines - physical fundamentals
- planning of hydro power stations: hydrological surveys, layout, power plan
- needs and requirements for energy storage
- fundamental options for power storage
- properties of storage technologies, pros and cons, application ranges, potential, development state, project examples
- pumped storage plants: fundamentals, electromechanical equipment, new approaches

#### **Intended Learning Outcomes:**

After successful participation in the module, students will be able

- to apply important and mainly used modelling techniques and calculation methods of water management
- to assess their application areas and limitations
- to design a reservoir under the aspects of hydrology and water resources management
- to describe, identify and assess established and newly proposed technologies of hydropower and energy storage
- to explain and assess the physical foundations of the energy conversion as well as the fundamental approach in planning hydropower projects
- to evaluate hydropower project plans and to perform planning themselves.

#### **Teaching and Learning Methods:**

- lecture style
- practical examples
- coordinated moodle tests (voluntary)

#### **Media:**

- PowerPoint presentations with film sequences and computer animations
- blackboard exercises
- moodle tests (voluntary)
- lecture notes in moodle

#### **Reading List:**

see lecture notes

**Responsible for Module:**

Dr.-Ing. Richard Huber (richard.huber@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Sustainable Water Resources Management (Vorlesung, 2 SWS)

Huber R, Scherbaum S

Hydro Power and Energy Storage (Vorlesung, 2 SWS)

Reisenbüchler M [L], Reisenbüchler M, De Vos L, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Elective Modules | Wahlmodule

### Module Description

#### BGU46026: Alpine Hazards | Alpine Naturgefahren [Ri+Kr]

##### *Alpine Hazards*

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written, closed book test of 120 minutes duration. It consists of theoretical questions, practical tasks and calculations. Only a simple scientific calculator and a dictionary are allowed aids.

In the exam, the students demonstrate by answering theoretical questions that they can explain the main processes in alpine watersheds and analyse them concerning the flows of water, debris, the influence on land mass movements and the resulting hazard potential. Furthermore, they show that they understand the working mechanisms of measures for hazard mitigation in mountainous regions. On the basis of practical examples, they show that they can analyse realistic situations and apply mitigation measures in targeted strategies for alpine hazards. Through calculation tasks they prove that they can assess the quantitative aspects of the hazard side and the measure side.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in Geology and Water Management.

#### Content:

Part 1: "Water Management in Mountain Regions"

The students get an introduction on the objectives and means of protective watershed management in alpine regions. The processes in natural landscapes, the relevant influencing factors on runoff and debris flow, the alpine water balance and relevant information sources



for planning are outlined. On basis of this fundamental aspects the development of protection concepts, including strategies, requirements and boundary conditions are explained.

Finally the preventive measures with focus on constructional aspects like hydraulic and biological engineering, the management of alpine protective forest and measures for avalanches control as well as aspects of regional planning are presented and discussed.

## Part 2: "Process analysis, Modelling and Mitigation of Alpine Hazards"

The lecture will introduce process understanding of gravitational, nival, glacial and periglacial Alpine Hazards in dynamically changing mountain environments. This includes physical and mechanical aspects of process understanding and stochastic descriptions of magnitude and frequency patterns. On basis of this profound understanding, we will introduce benchmark approaches of how to model and anticipate selected gravitational, nival, glacial and periglacial Alpine Hazards.

These approaches will be evaluated with respect to the presently observed and anticipated Environmental Change in Alpine regions. This will be integrated into the development of sustainable adaptation and mitigation strategies in dynamic Alpine Environments. Best practice examples from different mountain environments will be assessed in a final step.

### **Intended Learning Outcomes:**

After a successful participation in the module the students are able to:

- understand the fundamental natural processes in alpine watersheds,
- understand the main issues in water and debris flow management
- understand the full range of gravitational, nival, glacial and periglacial Alpine Hazards in dynamically changing mountain environments
- analyse the relevant strategies and tools for protection works against alpine hazards
- apply scientific and practical strategies for process understanding, anticipation and mitigation of Alpine Hazards

### **Teaching and Learning Methods:**

The module consists of a lecture series. The theoretical framework of processes and dynamics of alpine hazards will be presented in the lecture. Practical Examples illustrate strategies and measures for the anticipation and mitigation of hazards. Furthermore, students are encouraged to study scientific literature in order to enrich the discussion of the issues. In class exercises, selected examples are calculated and distinct quantitative tasks are shown.

### **Media:**

Blackboard work and PowerPoint presentation.

### **Reading List:**

Script and PowerPoint slides provided from lecturers.

**Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Prozessanalyse, Modellierung und Vorbeugung/Schutzmaßnahmen für Alpine Naturgefahren  
(Vorlesung, 2 SWS)

Krautblatter M, Rimböck A, Scandroglio R

Water Management in Mountain Regions (Vorlesung, 2 SWS)

Rimböck A ( Fuchs Y ), Fuchs Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46027: Rapidly varying Flows in Hydraulic Engineering | Abrupte Strömungsänderungen im Wasserbau [Rapid]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a project work. The project work consists of a written preparation and an accompanying presentation with an oral discussion.

The project work will be performed in groups of 2 students. Within the project work an advanced hydraulic system will be deeply investigated. The students have to identify the weaknesses of the given hydraulic systems, propose possible counter measures and prove their decision by transient computations. On the basis of the project work, the students show that they are able to implement and modify numerical approaches, compute the pressure and velocity distributions along a given system and evaluate the system characteristics. The methodology and result of the project work has to be documented in a written project report (15-20 pages).

The following oral discussion examines the work done for each student individually. They have to recall the main concepts and contents, explain and modify simple hydraulic systems and evaluate the system characteristics.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The students should know the basics on applied hydromechanics or fluid mechanics, e.g. Hydromechanics, module no. BV000013

#### Content:

Closed conduits – Rapidly varied flows in pipes.

- Main equations, boundary and initial conditions and solution.
- Transient pipe operation modes, like starting a pump or turbine.
- Water hammer and its control.

- Overpressure, cavitation and column separation as causes of damage.
- Utilizing a water hammer to pump water. (experimental work)

Rapidly varied open channel flows.

- Main equations (Saint-Venant), boundary and initial conditions and solution.
- Propagation of free surface waves.
- Surge wave and their meaning.
- Landslide in reservoirs.

Numerical description and implementation

- Simple applications using EXCEL.
- Advanced application using MatLab or Octave.

### **Intended Learning Outcomes:**

After successful completion of the module the students are able to explain the behavior of rapidly varied flows in closed conduits as well as in open channel flows. They understand water hammer and open channel phenomena as well as the working principle of a hydraulic ram pump and processes of landslides waves in reservoirs. They can describe the method of characteristic and finite differences method. They are able to compute and modify the simple hydraulic systems using Excel or Matlab. They will be able to calculate the pressure and velocity distribution along a pipeline systems as well as water level and velocity distribution along an open channel. For closed closed conduits system the students will be able to judge the numerical result as well as the system characteristics by evaluating the temporal and spatial pressure and velocity distributions.

### **Teaching and Learning Methods:**

The flipped classroom concept is applied. For your preparation there are explanatory videos and reading material provided, which you go through at home on your own for preparation. In the classroom, which are held as online courses, further content is presented and discussed. In addition, the results of the last task are presented by students and the new weekly task is outlined. After the online session you have to extend your learning by finishing the task of the week at home. Step-by-step the codes will be developed building up the basis for you project work. The project work is accompanied the by student's feedback sessions. Hereby the students have the opportunity to explain their project methodology and discuss open questions with the audience. The audience on the other hand should critically question the project methodology and give constructive feedback (student's feedback).

### **Media:**

Presentations on the blackboard; experiments in the classroom; calculations in PCs using Excel and MatLab or Octave.

### **Reading List:**

Chanson, H. (2004). "Environmental Hydraulics of Open Channel Flows." Elsevier Butterworth-Heinemann, Oxford, UK, 483 pages (ISBN 0 7506 6165 8).

[http://espace.library.uq.edu.au/list/?cat=quick\\_filter&search\\_keys\[0\]=tsunami+surge](http://espace.library.uq.edu.au/list/?cat=quick_filter&search_keys[0]=tsunami+surge)

**Responsible for Module:**

Tobias Liepert ([tobias.liepert@tum.de](mailto:tobias.liepert@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Rapidly Varying Flows in Hydraulic Engineering (Vorlesung, 4 SWS)

De Vos L ( Dallmeier A, De Vos L ), Dallmeier A, Liepert T, Reisenbüchler M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46032: Hydraulics in Water Engineering Laboratory | Laborübung Wasserbauhydraulik [HWEL]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>50   | <b>Contact Hours:</b><br>40          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

- Moodle short-test (general questions): admission requirement, not graded
- Laboratory report: weighting 40%
- Presentation of results (with discussion for presence): weighting 60%

The short test ensures that the students have the necessary basic knowledge of the experimental topics.

In the laboratory report, the experimental results are documented.

In the presentation of the results for selected topics, it is to be demonstrated that the students have the required deeper understanding.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Hydraulic Engineering (recommended)
- Basic Module for hydraulic engineering and water management (recommended)
- Supplementary Module for hydraulic engineering and water management (recommended)

#### Content:

In the lecture "Hydraulics in Water Engineering" of the Master's degree programmes "Civil Engineering" and "Environmental Engineering", various complex flow conditions are dealt with, which hydraulic engineers are frequently confronted with in practice.

By illustrating these hydraulic processes in a physical model, students can gain a better understanding and at the same time be introduced to the practical use of measuring instruments and the evaluation of measurement data.

The following topics are covered:

- efficiency of weirs
- influence of weir pillars on the efficiency of weirs
- pressure profile on the weir shape
- characteristics of flap gates
- piano key weirs
- shaft spillway, side channel and chutes
- deep outlets
- bottom outlets
- stilling bassins
- surge chambers and water hammer
- cavitation

**Intended Learning Outcomes:**

After successful completion of this module, the students have a deep understanding of the complex hydraulic problems dealt with and can reliably work on them in their further professional life.

**Teaching and Learning Methods:**

- Introduction lecture (online via Zoom)
- one week of supervised exercises at the Hydro Lab in Obernach: measurements on the 8 subjects on physical models (each topic ½ day, in small groups), alternatively videos of the tests ! free accommodation in VAO's guest house for the duration of the course !
- evaluation and presentation of the results

**Media:**

Script, table work, exercise sheets, PowerPoint, movies

**Reading List:**

see lecture notes

**Responsible for Module:**

Dr.-Ing. Richard Huber (richard.huber@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Laborübung Wasserbauhydraulik (Übung, 3,5 SWS)

Huber R [L], Huber R, Scherbaum S, Schlagenhauser M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU46033: Laboratory and Field Exercises at the Oberrach Lab | Modelltechnische und flussbauliche Übungen an der Versuchsanstalt Oberrach [VAO\_2016]** *Block Course VAO*

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                                |
|--------------------------------|----------------------------|----------------------------------|------------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer<br>semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45                    |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Discussion, presentation (information on individual knowledge level in group work, application of acquired knowledge to project examples), report, aids allowed

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basic and supplementary module hydraulic engineering and water management or corresponding Bachelor courses

#### **Content:**

Five-day block course + report

1 day theory: Fundamentals of hydraulic engineering modeling experiments, presentation of the current model tests in Oberrach.

4-day practice: Carrying out experiments on current hydraulic engineering models (measuring, documenting, evaluating and evaluating as well as presenting and discussing the results).

Detailed report on the model projects and the results obtained.

#### **Intended Learning Outcomes:**

After passing this course, students are able:

- to apply by means of practical work with running water in-depth hydrological knowledge to examples.
- to understand and successfully deal with questions of current hydraulic engineering projects.



**Teaching and Learning Methods:**

Lectures on the preparation of the necessary basics, guided tour through the experimental facilities with the current hydraulic engineering projects for the transfer of the basics to the practice, three-day group work in the laboratory for the practical experience, own presentation for the analysis and summary of the produced results, writing a detailed report.

Free accommodation in VAO's guest house for the duration of the course!

**Media:**

Lecture (90 min), 2-hour guided tour through the experimental halls in Obernach, 3 days group work on hydraulic model experiments, 1 day presentation and discussion, writing a report.

**Reading List:****Responsible for Module:**

Arnd Hartlieb (arnd.hartlieb@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modelltechnische und flussbauliche Übungen an der Versuchsanstalt Obernach (Übung, 3 SWS)

Hartlieb A [L], Hartlieb A, Scherbaum S, Schlagenhauser M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46034: Hydraulic Machinery and Plants Laboratory | Laborübung Hydraulische Maschinen und Anlagen

*Laboratory Exercises HMA*

Version of module description: Gültig ab summerterm 2016

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>30   | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Brief examination and written elaboration of test results.

The brief examination makes sure students have understood the fundamentals needed to conduct and understand the experiment. In the report, the students describe the experimental setup and the realisation of the experiment. They evaluate the measured data, represent them graphically and discuss their agreement with the theory. In doing so, they show that they are capable of conducting an experiment correctly as well as of representing and interpreting the experimental results.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basic knowledge of hydromechanics

#### Content:

Demonstration of hydraulic machinery and experimental techniques. Small groups of 5 participants perform measurements on pumps, water turbines and plant components and evaluate the results.

The following experiments are conducted:

- Measurement of pressure, pressure losses, flow velocity and discharge in pipes and in open flumes
- Determination of the operational characteristics (performance charts) of a centrifugal pump, a Pelton and a Francis turbine

**Intended Learning Outcomes:**

The students are able to understand the machinery and the flow phenomena connected with hydro power plants.

**Teaching and Learning Methods:**

lecture for imparting the theoretical background,  
discussion and deepening of the topics in the group sessions,  
demonstration and hands-on experiments on hydraulic machinery  
application of the knowledge in writing technical reports

The chosen course form makes sure that students understand the fundamentals required for the understanding of the experiment. While performing the experiments and writing up the reports the students learn to understand the flow phenomena by hands-on experience as well as to conduct an experiment correctly and to present and interpret the results obtained.

**Media:**

printed manuscript, power point presentations in the lectures

**Reading List:**

Reading list given in the manuscript

**Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Laborübung Hydraulische Maschinen und Anlagen (Übung, 2 SWS)

Alapfy B, Scherbaum S, Schlagenhauser M, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU46041: Implementation of Water Policy and Water Legislation | Umsetzung von Wasserpolitik und Wassergesetzgebung [GRA\_SEM]**

*Implementation of integrated water resource management in Bavaria and abroad, based on practical examples*

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination consists of an oral lecture (20 ') in the context of the seminar as well as a written elaboration of max. 10 pages. The weight is 50/50.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basic knowledge in water management e.g. by attending the lecture "International Water Policy and Law" in the winter semester

#### **Content:**

The seminar is composed of three pillars:

##### 1. Input from Bavaria

In cooperation with guest lecturers from various Bavarian authorities and associations (e.g. Ministry of the Environment, District Office, Water Management Office, municipal utility associations) current, real case studies from water law and politics in Bavaria are discussed and put into context with past experiences. These case studies should offer a deeper understanding of the content of the lecture in the winter semester and illustrate complex structures and the solution process. As far as possible, content-appropriate excursions can also be offered.

The topics include, for example:

- Good Water Governance principles and indicators and their application

- Processes in the water sector based on selected examples: complex structures, links and weak points
- Water law in practice, e.g. expulsion water protection area
- Interplay of state, parastatal and private actors in the Bavarian water sector
- Implementation of the EU-Water Framework Directive at local level
- Public participation: opportunities and challenges
- Ethical constraints for IWRM in case studies: Responsibility, Assessment, Strategies

## 2. Output international

At the same time, the students carry out their own research and work on a concrete international case study (for example in the SS 17 water sector in Kenya). A comprehensive stocktaking should be used to understand the problem situation and, based on the discussed solutions in Bavaria, develop adapted strategies and propose their practical implementation. The topics are edited and presented in the two-person team and are e.g.

- Basic water management data
- Structures and employees in the water sector
- Water management core tasks: monitoring, hydraulic engineering, protection and use
- Legal situation
- Financing
- Selected processes

## 3. Discussion and abstraction

During the seminar, there is plenty of room for discussion and development of new ideas. These should not only be incorporated into the processing of the international case study. As a result, a general questionnaire for the description and evaluation of water management systems worldwide will be developed during the seminar of lecturers and students.

### **Intended Learning Outcomes:**

After successful completion of the module the students are able

- to understand normative structures in the water sector.
- to assess the concrete challenges in the water sector, especially in an international context.
- analyze water management systems using technical and non-technical indicators.
- apply in-depth knowledge of integrated water resource management in practice.

### **Teaching and Learning Methods:**

Theoretical seminar contents are presented in the form of a lecture by the lecturers, supported by PowerPoint presentations and blackboard work. Accompanying concrete case studies are worked on. A lot of room for discussion enables the students to get involved, to intensify connections and to work out their own solution proposals for their sub-task. During the seminar, the students present their subtasks as part of a lecture.

**Media:**

PowerPoint presentations  
Material and plans of case studies  
Video clips

**Reading List:**

See description of the seminar

**Responsible for Module:**

Patalong, Hannah

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU46047: River Management - Technical, Ecological and Practical Aspects | Flussgebietsmanagement - technische sowie ökologische Rahmenbedingungen und Fallbeispiele [RMTEP]**

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                   |                                                |
|--------------------------------|-----------------------------|-----------------------------------|------------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer<br>semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120   | <b>Contact Hours:</b><br>60                    |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The examination consists of a written report based on the knowledge obtained from both courses within this module:

- Sustainable river management – technical and ecological needs (winter term)
- Modeling of Habitat for Fish and Invertebrates in Rivers (summer term)

The report should be about 7500 (+/- 1000) words, which will be performed as group work of 2 to 3 students plus two mid-term presentations, one per semester.

With the report, the students demonstrate their ability to apply respectively develop comprehensive river management strategies by working on different case studies with technical or ecological needs that require action in river basins. The written group report has two main parts corresponding to the two courses within this module.

In the first part of the group report, the students analyze a large-scale technical or ecological problem situation, autonomously create solution strategies, and, with the help of a developed criteria catalogue and group discussions, decide on a preferred comprehensive river management strategy.

In the second part of the group report, the students demonstrate their ability to implement a selected small-scale strategy by evaluating advantages and disadvantages of different habitat modeling methods in a case study at an alpine torrent. The students further demonstrate their ability to complete the required field data collections, numerical modeling and habitat modeling techniques in a team environment.

The report will be supplemented by two presentations (large-scale river management strategies; Implementation of a small-scale strategy at a case study) to the whole group of about 10-15 min. and an additional 10-15 min. for questions from the audience. With the mid-term presentations the communicative competence will be assessed, while presenting first results and approaches.

By presenting their work, the students show that they know the fundamentals needed to develop comprehensive river management strategies and field work case studies, understand the involved

processes in a general way and can present their work in a concise and precise manner. The midterm presentations allow the students to present the developed large-scale river management strategies (1st presentation) and their case study concepts and setup (2nd presentation) and to receive feedback on ideas before developing them further/conducting their case studies. Furthermore, this creates a space for discussing the concepts and approaches with fellow students.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

Basic knowledge of hydromechanics and morphodynamics which will be taught in:

Hydraulic and Water Resources Engineering Basic Module BV000030

River Engineering and Hydromorphology BV170004

**Content:**

See course description:

- Sustainable river management – technical and ecological needs (winter term)
- Modeling of Habitat for Fish and Invertebrates in Rivers (summer term)

**Intended Learning Outcomes:**

After successful completion of the module the students are able

- \* to analyze river management issues regarding legal frameworks
- \* to understand different applications of river management and river modelling in real world situations
- \* to understand the interaction of technical and ecological needs in river basins
- \* to understand the interaction of hydraulic parameters and habitat evolutions
- \* to conduct field measurements in the context of habitat modeling at small alpine rivers
- \* to acquire data and post-process them for application in their models
- \* to evaluate river management measures and develop sustainable solutions
- \* to set up river habitat models
- \* to analyze the results of habitat modelling approaches
- \* to evaluate the impact / benefit of comprehensive river management strategies according to legal frameworks.

In summary, students will have a deeper comprehension for the integration of ecological questions in planning processes for civil structures and are able to create comprehensive river management strategies.

**Teaching and Learning Methods:**

See course description:

- Sustainable river management – technical and ecological needs (winter term)
- Modeling of Habitat for Fish and Invertebrates in Rivers (summer term)



**Media:**

See course description:

- Sustainable river management – technical and ecological needs (winter term)
- Modeling of Habitat for Fish and Invertebrates in Rivers (summer term)

**Reading List:**

See course description:

- Sustainable river management – technical and ecological needs (winter term)
- Modeling of Habitat for Fish and Invertebrates in Rivers (summer term)

**Responsible for Module:**

Hannah Schwedhelm (hannah.schwedhelm@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modeling of Habitat for Fish and Invertebrates in Rivers (Seminar, 2 SWS)

Rüther N [L], Reisenbüchler M, Rüther N

Sustainable river management – technical and ecological needs (Seminar, 2 SWS)

Schletterer M, Reisenbüchler M, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV170051: Energy Economics and Hydro Power | Energiewirtschaft und Wasserkraftanlagen

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                               |
|--------------------------------|-----------------------------|----------------------------------|-------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>one-time |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30   |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam in this module is a written exam of 60 minutes in which the students have to answer questions in the field of energy topics, both economics and technical aspects in a closed books exam.

The comprehension of the lecture contents is also checked by some transfer questions, which are oriented on the presented exemplary areas of application.

#### Repeat Examination:

#### (Recommended) Prerequisites:

For Master students in Environmental Engineering:

Course only available as part of module "Energy Economics, Hydro Power and Energy Storage" (BGU46023).

Bachelor in Civil Engineering or Environmental Engineering.

#### Content:

Energy mix, power gap, increase of oil price, price fixing, nuclear phase out, grid stability, primary energy reserves, Kyoto protocol, CO2 emission trading, power prices, power trading, security of supply, environmental compatibility: These are the topics dominating the news when it comes to energy economics. How do these issues relate to each other? Which rules do energy economics follow? Conventional power or renewable energies: Contradiction or complement? What about the Interaction between energy economics and legislation, society, media or politics?

Hydro power plays a particular role within energy economics. Therefore the second part of the lecture deals with hydro power, being the most important renewable energy. Questions to be discussed will be: What are the potentials of hydro power? What is hydro power's relevance concerning the power mix? Based on a real example of a hydro power project issues as approval procedure, economics calculation, planning, construction, operation and maintenance strategy will be presented. Also this part of the lecture will demonstrate the numerous interfaces between engineering and other aspects linked to it.

**Intended Learning Outcomes:**

At the end of the module students are able to contribute to discussions with the various stakeholders on energy economics and know the various options of power production and its implications. They get an insight in the complex structure of energy and power supply from upstream to downstream.

**Teaching and Learning Methods:**

The lecture is aimed at providing insight into the various aspects of energy economics and at imparting knowledge to the engineer as a basis for working in an unusual and interesting environment. PowerPoint presentation and blackboard explanation for visualizing the topics. There are also discussions with the students during the lectures so they can get a deeper insight in practical experience with the topics.

**Media:**

PowerPoint presentation and blackboard explanation.

**Reading List:**

**Responsible for Module:**

Yannic Fusch (yannic.fuchs@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV460012: Rivers as an Ecosystem | Fließgewässer als Lebensraum [KS\_4]**

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The written module examination (120 min) consists of two thematic fields, in which the students have to answer simple questions on eco-hydraulics and aquatic ecology without any tools. In addition, the understanding of the learned design methods will be examined by simple transfer tasks, which are based on the presented examples. Further, there will be questions regarding the interdisciplinary understanding (cross-cutting on: hydraulic - eco-hydraulics - aquatic ecology).

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Participation in modules:

"Grundmodul Wasserbau und Wasserwirtschaft", module no. BV000030

and

"Ergänzungsmodul Wasserbau und Wasserwirtschaft", module no. BV000048

#### **Content:**

The module combines the two topics Eco-Hydraulics and Aquatic Ecology, thus comprehensively treating the habitat in watercourses.

Eco-Hydraulics:

- Flora and fauna in and around river basins; meadow vegetation
- Interaction between the river and catchment area
- Continuity: requirements, possible forms, structural realization, regulations

- Design and calculation of fishways and ramps
- Water Framework Directive Water Act

**Aquatic Ecology:**

- Aquatic habitats and aquatic ecosystem types; life support services and threats; gas budget, trophic interactions, nutrients and their dynamics
- lotic ecosystems as dynamic systems: specific features, functions and threats, river continuum concept, bioindication
- lentic ecosystems: ecological classification, specific features, threats,
- case studies: biodiversity, extinction and threats to aquatic ecosystems; conservation biology concepts
- ecotoxicological aspects: endpoints, xenobiotics and endocrine disruptors; human impacts and effects of use on aquatic ecosystems

**Intended Learning Outcomes:**

After attending the module the students are able to:

- understand the basics of ecology and chemistry of waters and the interdisciplinary relationships and specific characteristics of aquatic ecosystems
- apply the design rules to retrieve the river continuity
- analyse the temporal and spatial distribution of biodiversity and productivity in aquatic ecosystems
- estimate and assess effects of human intervention on aquatic ecosystems

**Teaching and Learning Methods:**

The module consists of a lecture. The theoretical course contents are presented by the lecturer and supported by PowerPoint presentations and whiteboard notes. Accompanying exercises and discussions of relevant case studies allow students to participate and to intensify learned contexts. As a part of the lecture, field-specific group work in the classroom is included, in which the students solve simple calculation and discuss case studies independently and present their results afterwards.

**Media:**

Blackboard; PowerPoint presentation; Calculations

**Reading List:**

Schwörbel, Jürgen: Einführung in die Limnologie, Springer Spektrum 2013, ISBN-13: 978-3827421531

Primack, Richard B.: A primer of Conservation Biology, Palgrave Macmillan 2004, ISBN-13: 978-0878937288

Pullin, Andrew S.: Conservation Biology, Cambridge University Press 2002, ISBN-13: 978-0521644822

Helfman, Gene S.: Fish Conservation, Island Press 2007, ISBN-13: 978-1559635967

Postel, Sandra & Richter, Brian: Rivers for Life: Managing water for people and nature, PAPERBACKSHOP UK IMPORT 2003, ISBN-13: 978-1559634441

Di Giulio, Richard T, & Hinton, David E.: The toxicology of fishes, CRC Press, 2008, ISBN 0203647297, 9780203647295

**Responsible for Module:**

Dr.-Ing. Markus Reisenbüchler (markus.reisenbuechler@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Rivers as an Ecosystem (Vorlesung, 4 SWS)

Rüther N [L], Rüther N, Geist J, Reisenbüchler M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV460014: Environmental Hydrodynamic Modelling | Hydrodynamische Modellierung für Umweltingenieure [EHDM]

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Formal assessment is based on two components: homework assignment and project work.

During the course, problem sets will be assigned. Homework solutions are the result of individual effort. However, group discussions of the concepts covered on the homework and review of the course material is encouraged. The students show that they are able to understand

- Basics of analytical and numerical approaches relevant to environmental hydraulic problems.
- Elementary programming concepts using the basic MATLAB architecture and mathematical / numerical routines.

The students are required to complete one class project. The project will be applications of HEC-RAS software to real problems. Similarly to homework assignment, project work and report will also be done individually. We expect a 10-15 page write-up about the project, which should clearly and succinctly describe the project goal, methods, and numerical results. At the end of the course, each student will be given 10 minutes for the oral presentation of their project, with an additional 5 minutes for questions. The project work will be graded on the basis of

- Their understanding of the overall course material, and
- Their ability to work independently with the relevant software applications.

The nominal subject grade is a weighted sum of the assignment grade (40%), the project report grade (30%) and the project presentation grade (30%).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Content:**

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Intended Learning Outcomes:**

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Teaching and Learning Methods:**

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Media:**

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Reading List:**

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Responsible for Module:**

PD Dr.-Ing. habil. Minh Duc Bui (bui@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Environmental Hydrodynamic Modelling (Vorlesung, 2 SWS)

Bui M

Environmental Hydrodynamic Modelling II (Vorlesung, 2 SWS)

Bui M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### **BV460019: Inland Navigation Management and Constructions | Verkehrswasserbau und Wasserstraßen**

Version of module description: Gültig ab winterterm 2012/13

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The exam in this module is a written exam of 60 minutes in which the students have to answer questions in the field of inland navigation, both technical aspects and economic aspects, without additives in a given time. The comprehension of the topics contents is also stimulated by transfer questions, which are oriented on the presented exemplary areas of application.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Bachelor degree in Civil- or Environmental Engineering

#### **Content:**

1. Traffic system ship/waterway
  - Transport economics, (transport volume, transport services, transport development)
  - Waterways network (structure, classification, perspectives)
2. Dynamic of inland waterway vessels
  - Handling equipment for manoeuvring (propeller, rudder)
  - Flow dynamics of the ship
  - Fairway dimensions for single trip and oncoming traffic
  - Cross-sectional geometry of the fairway
3. Natural inland waterways
  - River training measures (groynes, longitudinal training, bank protection)
  - Management of bed-load transport

#### 4. Locks

- Types of locks
- Design principles
- Filling- and emptying systems
- Equipment of locks
- Maintenance management
- Entrance and exit basins of locks
- Examples for the extension of entrance and exit basins of locks

#### 5. Artificial inland waterways (canals)

- Historical canals (Canal du Midi, Ludwig-Donau-Main-Canal)
- Modern canals (standard cross-sections, stability of dams, watercrossing buildings)
- Example: waterway junction at Magdeburg (canal bridge, water-saving locks, ship lift)

#### 6. Environment protection, nature protection, preservation of the countryside

- Legal bases
- Taking into account regarding the maintenance of waterways (maintenance schemes, deposition of dredged material)
- Consideration for extension and new building measures (environmental impact assessments, assessments of impacts on the countryside)
- Requirements of the European Water Framework Directive
- Ecological fish migration facilities at impounded waterways

#### **Intended Learning Outcomes:**

After a successful participation in the module students are able to:

- understand the economic importance of waterways in inland areas with respect to transport capacity;
- analyse the principles on the hydraulic interaction between ship and waterway;
- comprehend the main construction types, operation and maintenance of natural and artificial waterways including aspects regarding environment protection, nature protection and preservation of the countryside.

#### **Teaching and Learning Methods:**

In order to complete the module successfully, the transfer of knowledge must be predominantly through practical examples. These examples of waterways from all over Germany can best be provided through a slide presentation. Where possible, video clips will be presented in order to visualize the complicated dynamics of inland ship transport. At the end of the module, a one-day excursion is offered in order to include in the transport hydraulic structures and construction sites.

#### **Media:**

PowerPoint presentation

**Reading List:**

Presentation slides as lecture script

**Responsible for Module:**

Franz Zunic (franz.zunic@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Verkehrswasserbau und Wasserstraßen (Vorlesung, 2 SWS)

Heinzelmann C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### ED130007: Introduction to Machine Learning and Applications in Hydraulic and Hydro-Morphology | Einführung in Machine Learning und Anwendungen in der Hydraulik und Hydromorphologie [MLHM]

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of the preparation of a written report that contains the process steps and results of a project work (40%), a 15min talk about the project results with subsequent discussion (40%) and regular discussions about problem sets with the lecturer during the course (20%).

By the delivery of the written report (15 - 20 pages) about the project work (in a group of max. 2 students), students show their ability to independently apply the learned methods from the area of machine learning in classic hydraulic or hydromorphological problem cases. The report should clearly and succinctly describe the project goal, the applied methods and the acquired model results.

With help of the presentation and talk about the project, the students demonstrate their understanding of the essential elements of the project work and their ability to demonstrate them to an audience and to justify their approaches.

With help of the regular discussions during the course it is ensured that the students show their understanding of the fundamental concepts of machine learning models and necessary programming concepts with MATLAB, so they are able to develop their problem solving steps for the project work.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Bachelor Degree in Civil or Environmental Engineering with basic knowledge of hydraulic and hydro-morphology.

This is an introductory course on machine learning and requires no previous knowledge of machine learning and programming. However, a basic understanding of MATLAB helps but is not necessary.

**Content:**

The module covers the following topics:

- Necessary mathematical prerequisites
- Necessary programming skills in MATLAB
- Introduction to machine learning
- Regression vs. Classification
- Neuronal Networks: architectures, algorithms, applications
- ML model setup in MATLAB
- ML applications in the field of hydraulics and hydromorphology
- Setup of ML models for problem cases in hydraulics and hydromorphology

**Intended Learning Outcomes:**

By the end of the module, the students understand the fundamental principle of Machine Learning (ML) Models and are able to program simple ML models with help of MATLAB.

Furthermore, the students can apply a ML model to a real problem case in the field of hydraulics and hydromorphology and create independently a solving concept for a problem setup.

**Teaching and Learning Methods:**

The module consists of lectures, hands-on exercises in computer-labs and group works.

It covers synchron online-teaching with lectures incl. computer-lab and additional consultation hours and forums for the project work supervision.

During the course the students are required to complete small problem sets individually and one project work (in a group of max. 2 students).

**Media:**

Zoom  
PowerPoint  
panel work  
computer-labs  
exercise sheets

**Reading List:**

1. Hagan et al. Neural Network Design, 2nd edition, 2014;  
<https://hagan.okstate.edu/nnd.html>
2. Abu-Mostafa et al. Learning from Data, a Short Course, 2012.
3. Mathworks, Neural Network Toolbox User's Guide, 2017.

Online version:

**Responsible for Module:**

PD Dr.-Ing. habil. Dipl.-Math. Minh Duc Bui (bui@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Einführung in Machine Learning und Anwendungen in der Hydraulik und Hydromorphologie  
(Vorlesung mit integrierten Übungen, 4 SWS)

Bui M [L], Bui M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

**Field of Study 4: Hydrogeology | Vertiefung 4: Hydrogeology****Required Modules | Pflichtmodule****Module Description****BGU66022: Groundwater Hydraulics | Grundwasserhydraulik**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

**Description of Examination Method:**

The module is validated by a written exam (90 min). In the written exam the students demonstrate their ability to understand basic principles in groundwater hydraulics (basic terms of ground water hydraulics, mathematical models to describe the water movement within the porous medium (Darcy's Law, potential flows), continuity for confined and unconfined aquifers, differential equations describing subsurface flows and their solutions) and apply these principles on simplified engineering and hydrogeological problems. Besides the students have to solve arithmetic problems stemming from hydrogeological case studies and performed hydraulic field tests to train their skilled theoretical knowledge. In the written exam, a hand-written A4 sheet is allowed as auxiliary means together with a non-programmable pocket calculator.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

Basic understanding of Hydrogeology, Mathematics, Physics and Chemistry is recommended. Students should be interested in working with mathematical models and in applied hydrogeology. It is mandatory that students have attended successfully the module Hydromechanik (B.Sc.) or an equivalent and have some basics in geology (Introduction to Geology, BGU67002). It is recommended that students have fundamental skill in Excel and Matlab or a similar programming language.

**Content:**

In the module are taught the fundamentals of Groundwater Hydraulics and the essential elements of Advanced Hydrogeology:

#### Groundwater Hydraulics:

- Fundamental concepts and terms in Groundwater Hydraulics
- Fundamentals and flow in a porous medium (Darcy's law and generalizations)
- Conservation laws (differential equations) for mass and momentum in confined and unconfined groundwater aquifers
- Solutions of the differential equations in simple flows (uniform flow, flow towards a well, dimensioning of a well)
- Unsteady flow towards a well, pumping test
- Fundamentals of numerical methods to solve groundwater flows

#### Advanced Hydrogeology:

- Fundamentals of water flow in the saturated zone (Darcy's law)
- Analysis of pump tests in complex porous aquifers
- Analysis of pump tests in fractured rocks with matrix porosity (Double-porosity systems)
- Soil water transport
- Flooding and feedback to groundwater
- Redox processes in a river (nitrogen cycle)

#### Intended Learning Outcomes:

After participating in the module, the students are able to:

- understand and apply basic concepts in groundwater hydraulics and solve complex hydrogeological problems in order to analyse groundwater hydraulic problems and evaluate groundwater resources and flow, to interpret hydraulic tests in porous and fractured groundwater media and to understand chemical field data
- apply mathematical models to describe simplified groundwater flow and hydrogeological problems
- evaluate and interpret hydraulic field tests (including pumping tests in unconsolidated and consolidated rock) concerning storativity and transmissivity of the aquifer
- analyse biogeochemical processes in aquifers related to the nitrogen cycle
- describe hydraulic questions by using mathematical equations and implement them in models

#### Teaching and Learning Methods:

The module Groundwater Hydraulics consists of a lecture and a lecture with integrated exercises. Groundwater Hydraulics and Advanced Hydrogeology. The basic knowledge in groundwater hydraulics is taught by class room lectures and tutorials with exercises examples. The lecture is accompanied by a written script, homework exercises and matlab scripts which the students use to achieve programming skills.

The underlying teaching philosophy of the lecture Advanced Hydrogeology is problem-based learning. The core of the courses consists of a series of tutorials (6), which should expose the students to important hydrogeological questions, problems and methodologies. Each scientific topic will be started with a thematic refresher and a lecture. After the lecture there will be a tutorial and this tutorial trains the students' expertise by having 'hands-on' the models (self-programmed models in spreadsheets and professional software for data interpretation). This means students are working on the tutorials in class (computer room) in order to actively learn on formulating



and solving problems in the field of applied hydrogeology and biogeochemistry. At the end of each lecture a small group of students will discuss the results of the tutorial by short Power Point presentations.

**Media:**

Power-point presentation, black board, calculation exercises, pc-lab, discussion, recommended literature

**Reading List:**

Fetter CW (2001): Applied Hydrogeology, 4th ed. Prentice Hall, New Jersey, 598 pp.  
Langguth HR, Voigt R (2004): Hydrogeologische Methoden. 2. Ed, Springer, Berlin.  
Fetter, CW (1999): Contaminant Hydrogeology, 2nd ed. Prentice Hall, New Jersey, 500 pp. (1st edition: 1993).  
Domenico PA, Schwartz FW (1998): Physical and chemical hydrogeology. 2nd edition, Wiley.  
Appelo CAJ, Postma D (2006): Geochemistry, groundwater and pollution. Balkema, Leiden.  
Kinzelbach W, Rausch R (1995): Grundwassermodellierung - Eine Einführung mit Übungen. Borntraeger, Berlin, Stuttgart, 283 pp.  
Holzbecher E (1996): Modellierung dynamischer Prozesse in der Hydrologie - Grundwasser und ungesättigte Zone. S. Springer, Berlin, 364 pp.  
Rausch R, Schäfer W, Wagner Ch (2002): Einführung in die Transportmodellierung im Grundwasser. Borntraeger, Berlin, Stuttgart, 183 pp.

**Responsible for Module:**

Prof. Dr. Florian Einsiedl, f.einsiedl@tum.de, Chair of Hydrogeology

**Courses (Type of course, Weekly hours per semester), Instructor:**

Vertiefung Hydrogeologie für Umweltingenieure (Vorlesung mit integrierten Übungen, 2 SWS)  
Einsiedl F, Rein A, Wunderlich A

Grundwasserhydraulik (Vorlesung, 2 SWS)

Manhart M, Unglehart L

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU66043: The Saturated and the Unsaturated Zone: Process Understanding and Modelling | Die gesättigte und ungesättigte Zone: Prozessverständnis und Modellierung**

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120   | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination consists of a project work.

Students will complete a study project, containing the analysis of given hydrogeological problems and related tasks. The study project will be done in groups. Each group has to accomplish a written report on the project work (to be submitted after the course), and this report will be graded. The study project and report consists of two equally weighted parts. The first part shall contain a parameterized numerical groundwater model (FEFLOW). The second part includes laboratory work and a parameterized model for unsaturated flow and transport in MATLAB. Results obtained with these models should be described, discussion of the findings should be done and conclusions drawn, concerning the posed question/problem. Aims of this examination include to verify that students have understood basic concepts of flow and transport processes in saturated and unsaturated porous media and that they are able to apply those concepts for the solution of problems. By being exposed to typical hydrogeological questions, the ability of students building up an own numerical model and to “translate” hydrogeological conditions into professional numerical flow and transport models will be measured, as well as the ability to carry out simulations using these model and to interpret the results with respect to hydraulic processes.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basic understanding of Hydrogeology, Geology, Environmental Geology, Mathematics, Physics and Chemistry is recommended. Students should be interested in working with mathematical models. It is recommended that students have visited module Groundwater Hydraulics, environmental monitoring, fluid mechanics (e.g. the BSc courses Grundmodul Hydrologie, Umweltmonitoring und

Risikomanagement, Fluid Mechanics), and Environmental Geology (BV000118) and Introduction to Geology

### **Content:**

- Principles of groundwater movement, analysis of factors influencing groundwater flow
- Examples for applying groundwater models
- Acquiring and processing data for model input; interpolation techniques; data quality evaluation
- Setup of a hydrogeological model
- Numerical methods in groundwater modelling
- Setup of a numerical groundwater model; model discretization; boundary conditions; model parameterization
- Running simulations; model calibration and validation
- Interpretation and post-processing of results
- Hydrological surface processes driving soil moisture content
- Derivation of the flow equation in the unsaturated zone
- Introduction to implicit and explicit numerical methods for the solution of the unsaturated zone flow equation
- Flow in the unsaturated zone with OTHM
- Model Calibration, Inverse modelling
- Development of Matlab scripts for the solution of selected exercises

### **Intended Learning Outcomes:**

A student who has met the objectives of the course will be able to:

- apply simple groundwater flow and transport simulations by building an own FEFLOW model in order to describe and analyse water resources and flow in the saturated zone
- insert geological information to the numerical groundwater model
- evaluate simulations with respect to real observations, data and model uncertainties
- to understand complex hydrogeological problems and to describe them mathematically
- evaluate and interpret hydraulic field tests (including pumping tests in unconsolidated and consolidated rock)
- analyse biogeochemical processes in aquifers related to the nitrogen and sulphur cycle
- describe hydraulic questions by using mathematical equations and implement them in models
- to understand the basic processes controlling hydrological processes in the unsaturated zone
- to apply the flow equation for the unsaturated zone
- to create flow and transport modelling based on field measurements
- to apply the following tools: MATLAB and OTHM

### **Teaching and Learning Methods:**

The module consists of a lecture and exercise. The underlying teaching philosophy of the module is problem-based learning. The core of the courses consists of a series of tutorials, which should expose the students to important questions, problems and methodologies. The tutorials are supported by lectures, discussion and focused reading.

Each scientific topic will be started with a thematic refresher and a lecture. After the lecture there will be a tutorial, and this tutorial trains the students' expertise by having 'hands-on' the models (self-programmed models in spreadsheets and professional groundwater modelling software). This means students are working on the tutorials in class (computer room) in order to actively learn on formulating and solving problems in the field of hydrogeology, groundwater-soil-plant interactions and subsurface contamination.

**Media:**

Power-point presentation, black board, movies, pc-lab, discussion, recommended literature

**Reading List:**

Fetter CW (2001): Applied Hydrogeology, 4th ed. Prentice Hall, New Jersey, 598 pp.  
Langguth HR, Voigt R (2004): Hydrogeologische Methoden. 2. Ed, Springer, Berlin.  
Fetter, CW (1999): Contaminant Hydrogeology, 2nd ed. Prentice Hall, New Jersey, 500 pp. (1st edition: 1993).  
Domenico PA, Schwartz FW (1998): Physical and chemical hydrogeology. 2nd edition, Wiley.  
Appelo CAJ, Postma D (2006): Geochemistry, groundwater and pollution. Balkema, Leiden.  
Kinzelbach W, Rausch R (1995): Grundwassermodellierung - Eine Einführung mit Übungen. Borntraeger, Berlin, Stuttgart, 283 pp.  
Holzbecher E (1996): Modellierung dynamischer Prozesse in der Hydrologie - Grundwasser und ungesättigte Zone. S. Springer, Berlin, 364 pp.  
Rausch R, Schäfer W, Wagner Ch (2002): Einführung in die Transportmodellierung im Grundwasser. Borntraeger, Berlin, Stuttgart, 183 pp.  
Chiang, W.-H., & Kinzelbach, W. (2001). 3D-Groundwater Modeling with PMWIN (With CD-ROM). Springer. Retrieved from <http://www.amazon.com/3D-Groundwater-Modeling-PMWIN-With-CD-ROM/dp/3540677445>  
Holzbecher, E. (2012). Environmental Modeling: Using MATLAB. Springer.  
J. Bear, Hydraulics of Groundwater, McGraw-Hill, New York, 1979  
P.A. Domenico, F.W. Schwartz, Physical and Chemical Hydrogeology, J. Wilson & Sons, New York, 1990  
"PEST- Model interdependent parameter estimation users manual. Watermark computing. Australia  
Poeter, E. P. and M. C. Hill, 1998. Documentation of UCODE, a computer code for universal inverse modeling, U.S. Geological Survey, Water-Resources Investigation Report 98-4080

**Responsible for Module:**

Dr. Arno Rein, arno.rein@tum.de, Chair of Hydrogeology

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modelling Processes in the Vadose Zone (Vorlesung, 2 SWS)  
Chiogna G [L], Chiogna G

Grundwasser-Modellierung 1 (Übung, 2 SWS)  
Rein A, Zoßeder K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Elective Modules | Wahlmodule

### Module Description

#### **BGU54019: Numerical Modeling of Water Demand and Supply in Arid Regions | Numerische Modellierung von Wasserbedarf und -Versorgung in ariden Gebieten [OWHM]**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The exam consists of the development of a project (i.e. a numerical model with the software OWHM) to be presented in oral form (20 minutes presentation followed by a discussion). The exam will verify i) how the students understand basic concepts of water demand and supply in arid regions; ii) how the students are able to apply those concepts for the solution of realistic case studies.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Basic Module Hydrology (BSc)  
Groundwater modeling (MSc)

#### **Content:**

- Basics of water management in arid regions
- Introduction to MODFLOW-OWHM (One Water Hydrologic Model)
- Specific packages of OWHM and physical description of the processes
- Development of the case study
- Presenting a case study

#### **Intended Learning Outcomes:**

At the end of the module, students are able:

- i) to understand the basic principles behind water management in arid regions.

ii) to apply a physically based model to manage water resources in arid regions.

iii) to predict water availability according to specific water management conditions.

The course will provide to the students both the theoretical as well the practical knowledge to use MODFLOW-OWHM to solve water management issues in arid regions, including irrigation.

Upon completion of the modelling and management part the students will be able to evaluate different groundwater management strategies, to create flow and transport modeling based on field measurements and to apply them to determine water availability, to understand aquifer parameters and evaluate the sustainability of water management options.

### **Teaching and Learning Methods:**

Lectures (Power-Point-Presentation, blackboard), exercises (individual, small groups), homework (modelling exercise).

The teaching philosophy behind this module is based on the evidence that different study goals will be achieved using different approaches. While theoretical concepts and mathematical equations require an in-depth explanation, which is provided during the lectures, the understanding of a model requires hands-on learning, which will be provided during exercises and homework. During the lectures, the student will understand the theory, which is behind the model they are going to use in the exercises and homework. In this way, at the end of the module, they will be able to create their own model for the solution of flow and transport in porous media.

### **Media:**

Power-Point-Presentation

Blackboard

### **Reading List:**

- Chiang, W.-H., & Kinzelbach, W. (2001). 3D-Groundwater Modeling with PMWIN (With CD-ROM). Springer.

- One water hydrologic flow model: <https://pubs.er.usgs.gov/publication/tm6A51>

### **Responsible for Module:**

Prof. Dr.-Ing. Markus Disse ([markus.disse@tum.de](mailto:markus.disse@tum.de))

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Numerical modeling of water demand and supply in arid regions (OWHM) (Vorlesung, 2 SWS)

Disse M [L], Disse M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66024D2: Advanced Groundwater Modelling for Environmental Engineers | Fortgeschrittene Grundwassermodellierung für Umweltingenieure

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105   | <b>Contact Hours:</b><br>75                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a project work.

Students will complete a project work containing the analysis of given case studies on hydrogeological and hydraulic situations, subsurface contamination and related questions. This is to be done with help of mathematical modeling.

By exposing the students to defined “real world” hydrogeological cases, the project work measures the student’s competence to describe, analyze and evaluate hydrogeological problems with help of mathematical modeling. Students have to transfer and apply their knowledge obtained during the module. This includes an understanding of relevant processes in the soil-groundwater-plant system (water flow, contaminant transport and fate) and of interactions between groundwater and surface water. Adequate mathematical models have to be chosen and applied, and used models and model simulations have to be documented in the project work report. Based upon the model simulations, evaluations have to be done concerning hydraulic conditions and contaminant transport/fate in groundwater, soil and plants as well as concerning hydraulic interactions between groundwater and surface water. Obtained model simulations have also to be evaluated with respect to plausibility (comparison to available site information and measured data).

Project work will be done in groups. Each group has to accomplish a written report on the project work, and this report will be graded. The project work and report consists of two parts corresponding to the two courses. The report covers 20-30 pages in total. In order to recognize individual contributions, students shall document their contribution to subtasks within the project work and respective chapters of the report. The reports shall contain problem statements, results and findings concerning the case studies, as well as a discussion of the findings and a presentation of applied methods.

#### Repeat Examination:

Next semester



**(Recommended) Prerequisites:**

Basic understanding of Hydrogeology, Mathematics, Physics and Chemistry is recommended. Students should be interested in working with mathematical models. It is recommended that students have visited one of the following modules: BV660006 Hydrogeology I (Hydrogeologie I), BV660002 Groundwater Flow and Transport (Strömung und Transport).

**Content:**

This module deals on modeling hydrological and chemical processes in the soil-groundwater-plant system, as well as on modeling hydraulic exchange and feedback mechanisms between groundwater and surface water. Topics include:

Course Groundwater-Soil-Plant-Interaction:

- Soil and unsaturated zone (characteristics and processes)
- Plant physiology and functionality, plant-related processes in the environment
- Sorption and diffusion, microbes in the subsurface (microbial growth and degradation)
- Soil water balance and leaching, evaporation and transpiration, contaminant fate/transport in the unsaturated zone and within plants
- Set-up and application of analytical and water balance models for the soil-groundwater-plant system, for analyzing and evaluating water availability/flow and pollutant fate

Course Groundwater Modeling (Advanced):

- Contaminant transport in groundwater (processes and their mathematical description)
- Set-up and parameterization of analytical and numerical contaminant transport models, model application and interpretation of results
- Exchange and feedback mechanisms between groundwater and surface water and coupling of model codes
- Parameterization and application of the coupled groundwater-surface water model approach
- Evaluation of hydraulic situations with help of the simulation results

**Intended Learning Outcomes:**

A student who has met the objectives of the course will be able to:

- understand relevant processes in the soil-groundwater-plant system with respect to the water budget and contaminant transport and fate
- describe related environmental processes mathematically and develop baseline simulation models
- analyze hydraulic conditions and contaminant transport/fate in groundwater, soil & plants with help of modeling
- understand and evaluate hydraulic interactions between groundwater and surface water
- understand and apply the coupling of numerical surface water and groundwater models
- compare model calculations with observations and available site data and evaluate the obtained simulation results

**Teaching and Learning Methods:**

The module consists of two lectures with integrated exercises. The underlying teaching philosophy of the module is problem-based learning. The core of the courses consists of a series of tutorials,

which should expose the students to important questions, problems and methodologies. The tutorials are supported by lectures, discussion and focused reading.

Each of the scientific topics will be trained and discussed for one to three weeks with lectures and tutorials. Each topic will be started with a thematic refresher and a lecture. After the lecture there will be a tutorial, and this tutorial trains the students' expertise by having 'hands-on'. This means students are working on the tutorials in class (computer room) in order to actively learn on formulating and solving problems in the field of hydrogeology, groundwater-soil-plant interactions, groundwater-surface water interactions and subsurface contamination.

At the final part of the two courses (the last one or two sessions), case studies on hydraulic situations and subsurface contamination to be analyzed will be handed out (project work). Students will start with the project work in groups under supervision, where feedback will be given to each group by one-to-one discussions during the contact hours. Each group has to accomplish a written report on the project work at the end of the module (details see above). Working in groups trains the students' competence to carry out and complete their task (solving a hydrogeological problem) in a team. Individual contributions shall nonetheless be recognizable: students shall document their contribution to subtasks within the project work, reflected in respective chapters of the report.

#### **Media:**

Moodle e-learning platform, presentations, exercise hand-outs, pc-lab, recommended literature

#### **Reading List:**

Scheffer F, Schachtschabel P (2010): Lehrbuch der Bodenkunde. Springer, Berlin. (Older editions: Enke, Spektrum).

Trapp S, Matthies M (1998): Chemodynamics and Environmental Modeling: An Introduction. Springer, Berlin (German edition: Dynamik von Schadstoffen - Umweltmodellierung mit CemoS: Eine Einführung. Springer, Berlin, 1996)

Trapp S, McFarlane JC (1995): Plant Contamination. Lewis Publishers, London.

Holzbecher E (1996): Modellierung dynamischer Prozesse in der Hydrologie - Grundwasser und ungesättigte Zone. Springer, Berlin.

Schwarzenbach RP, Gschwend PM, Imboden DM (2002): Environmental Organic Chemistry. 2.Ed., Wiley, New York.

Anderson, M., Woessner, W. (1992): Applied Groundwater Modelling. Academic Press, Inc.

Kinzelbach, W. & Rausch, R. (1995): Grundwassermodellierung – Eine Einführung mit Übungen. Borntraeger, Stuttgart.

Kovarik, K. (2000): Numerical Models in Groundwater Pollution. Springer, Berlin.

Rausch, R., Schäfer, W. & Wagner, Ch. (2002): Einführung in die Transportmodellierung im Grundwasser. Borntraeger, Stuttgart.

#### **Responsible for Module:**

Arno Rein, arno.rein@tum.de

#### **Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrogeologische Fallbeispiele, Grundwasser-Boden-Pflanzen-Interaktion (Vorlesung mit integrierten Übungen, 2 SWS)

Rein A

Grundwassermodellierung (Fortgeschrittene) (Vorlesung mit integrierten Übungen, 3 SWS)

Zoßeder K, Rein A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66025: Applied Hydrogeology for Environmental Engineers | Hydrogeologie in der Praxis für Umweltingenieure

Version of module description: Gültig ab winterterm 2016/17

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Prüfungsleistung besteht aus einer schriftlichen Projektarbeit, die die Studierenden in Gruppen (drei bis vier Personen, abhängig von der Teilnehmerzahl) anfertigen und nach der Vorlesungszeit abgeben. Die Projektarbeit besteht aus einem zu bearbeitenden Fallbeispiel.

Mit der Projektarbeit wird überprüft, inwieweit die Studierenden in der Lage sind, anhand konkreter Fallbeispiele (jede Gruppe erhält ein separates Thema) aus der hydrogeologischen Praxis komplexe hydrogeologische Probleme zu erkennen und zu analysieren, adäquate Methoden zum Beantworten hydrogeologischer Fragestellungen anzuwenden und die gewonnenen Ergebnisse zu bewerten. Durch die Gruppenarbeit wird zudem die soziale Kompetenz der Studierenden geprüft, bei der Lösung berufspraktisch-relevanter Fragestellungen der angewandten Hydrogeologie, wie etwa die Erstellung eines hydrogeologischen Gutachtens, im Team ergebnisorientiert zusammenzuarbeiten.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Empfohlen sind Grundkenntnisse der Hydrogeologie, sowie der Mathematik, Physik und Chemie. Teilnehmer/Innen sollten an der Arbeit mit mathematischen Modellen interessiert sein. Empfohlene Lehrveranstaltungen im Vorfeld sind die Module BV660006 Abriss der Hydrogeologie und BV660002 Strömung und Transport.

#### Content:

Im Modul werden die Grundlagen für die praxisnahe Bearbeitung wesentlicher hydrogeologischer Arbeitsfelder (Altlastensanierung, Trinkwassergewinnung) vermittelt:

- Grundwasserbeschaffenheit (Grundlagenwiederholung)
- Probennahme (Boden, Grundwasser)

- Vorgehensweise bei der Begutachtung von Altlasten
- Bestehende Konzepte zur Sanierung von Boden und Grundwasser
- Wichtige (Berufs-)Zertifizierungen im Altlastenbereich
- Ausweisung von Trinkwasserschutzgebieten (Bemessungsverfahren, Antragsunterlagen, Schutzgebietsfestsetzung)
- Grundwassererschließung durch Brunnen und Quelfassungen (Vorerkundung, Planung, Ausschreibung, Baubetreuung, Pumpversuche, Datenerfassung, Auswertung, Analytik, Wasserrecht etc.)
- Erstellung hydrogeologischer Gutachten (Aufgabenstellung, Konzeptentwicklung, Angebotskalkulation, Datenerhebung, Projektdurchführung, Gutachten)

### **Intended Learning Outcomes:**

Nach der Teilnahme an der Veranstaltung beherrschen die Studierenden des Umweltingenieurwesens:

- die Grundlagen für die Erstellung eines hydrogeologischen Basisgutachtens, um diese in der hydrogeologischen praktischen Arbeit (z.B. im Ingenieurbüro) anzuwenden
- Gruppenarbeit bei der Lösung berufspraktisch-relevanter Fragestellungen der angewandten Hydrogeologie, wie etwa die Erstellung eines hydrogeologischen Gutachtens, im Team ergebnisorientiert anzuwenden.
- die Richtlinien und Vorgehensweise für Brunnenerschließungen, Quelfassungen und Ausweisung von Trinkwasserschutzgebieten anzuwenden

Desweiteren sind sie in der Lage:

- die Schritte in der Praxis (Datenrecherche, Probennahme, Datenbeurteilung, Dokumentation, Schlussfolgerung) und die entsprechenden wasserwirtschaftlich relevanten Regelwerke (WHG, Leitfäden, Merkblätter der Landesämter) für eine Beurteilung von Altlasten und von Sanierungskonzepten zu verstehen
- die berufsspezifischen Zertifizierungsmöglichkeiten im Altlastenbereich zu verstehen, um die beruflichen Anforderungen in der hydrogeologischen Praxis zu kennen.

### **Teaching and Learning Methods:**

Die Veranstaltung besteht aus einer Reihe von Vorlesungen, die mit praktischen Übungen ergänzt werden, wobei problembasiertes Lernen eine philosophische Grundlage bildet. Die Übungen spielen eine zentrale Rolle: Hier wird anhand von Praxisbeispielen die tatsächliche Anwendung der theoretischen Grundlagen der Hydrogeologie trainiert, welche wiederum in den Vorlesungsstunden vermittelt werden. In der Vorlesung werden zudem optional Gastvorträge von Fachleuten aus der Praxis zu speziellen Themen angeboten, wie etwa der Altlastensanierungspraxis oder den rechtlichen Grundlagen.

Die einzelnen Themen werden jeweils über 1-3 Wochen behandelt, wobei jedes Thema mit einer kurzen Auffrischung der hydrogeologischen Grundlagen begonnen wird. Hierbei werden die grundlegenden Fragestellungen im Plenum aktiv diskutiert. Daran schließen sich praktische Übungsstunden an, die eng mit Problemen aus der Praxis verbunden sind. Die Studierenden wenden hierbei hydrogeologische Konzepte/Methoden an, um aktiv die Formulierung und Lösung von typischen Problemen in der Praxis zu lernen, die im Bereich der Hydrogeologie und

Untergrundkontamination auftreten können. Die Übungen werden von den Studierenden während des Kurses unter Betreuung bearbeitet, wobei manche der Übungen zu Hause fertig gestellt werden sollen (in ca. 2 Stunden Eigenstudiumszeit; Besprechung in der darauffolgenden Sitzung). Am Schluss der Kurse (letzte ein bis zwei Termine) werden die Fallstudien ausgeteilt, die als Projektarbeit (Prüfungsleistung) gestellt sind. Die Studierenden beginnen in Gruppen von drei bis vier Personen daran zu arbeiten, wobei die Betreuer Feedback geben (individuelle Diskussionen mit den einzelnen Gruppen). Die Projektarbeiten stellen eine Synthese und Transfer-Anwendung der während des Kurses gelernten Methoden und (Bewertungs-)Techniken dar.

**Media:**

Powerpoint-Vortrag, Tafelbild, Übungsblätter, Übungen am Computer (Rechner-Raum), Auszüge aus der Literatur

**Reading List:**

LANGGUTH HR., Voigt R (2004): Hydrogeologische Methoden. 2. Ed, Springer, Berlin.

**Responsible for Module:**

Dr. Kai Zosseder, [kai.zosseder@tum.de](mailto:kai.zosseder@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrogeologie in der Praxis (Vorlesung mit integrierten Übungen, 2 SWS)

Zoßeder K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU66026: Shallow and Deep Geothermal Energy Use of Groundwater for environmental Engineers | Flache und Tiefe Geothermie von Grundwassersystemen für Umweltingenieure**

Version of module description: Gültig ab winterterm 2016/17

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Mit der Klausur (60 min) wird geprüft, inwieweit die Studierenden in Wissensfragen die physikalischen Grundlagen der Geothermie, die physikalischen, geologisch/hydrogeologisch relevanten Parameter und die geothermischen Prozesse beschreiben können sowie in praxisnahen Fragestellungen die Untersuchungs- und Berechnungsmethoden für die Planung und Auslegung oberflächennaher Systeme fallspezifisch anwenden, sowie die Ergebnisse aus der Datenauswertung von Feld- und Bohrdaten, auch hinsichtlich Unsicherheiten und Risiken in der Geothermie, analysieren und bewerten können.

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

Empfohlen sind Grundkenntnisse der Geologie (Einführung in die Geologie für Umwelting.), Hydrogeologie (Grundwasserhydraulik) und der Thermodynamik.

#### **Content:**

Im Modul werden den Studierenden die Grundlagen der Geothermie sowie die Vorgehensweise und andere wichtige Aspekte bei Planung, Bau und Betrieb von geothermischen Anlagen vermittelt. Die Inhalte sind im Einzelnen:

- Physikalischen Grundlagen des Wärmestroms im Untergrund
- Relevante Parameter zur Beschreibung geothermischer Systeme
- Lagerstättentypen geothermischer Systeme
- Verfahren zur Planung, Exploration und Gewinnung bei tiefen geothermischen Systemen

- Nutzungsvarianten von oberflächennahen geothermischen Systemen und ihre Planung und Auslegung
- Rechtliche Grundlagen bei der Nutzung von oberflächennaher und tiefer Geothermie
- Ökonomische Betrachtung von oberflächennahen Systemen
- Unsicherheiten und Risikoabschätzung bei geothermischen Nutzungen

### **Intended Learning Outcomes:**

Nach der erfolgreichen Teilnahme an den Modulveranstaltungen sind die Studierenden in der Lage:

- die Prozesse der Wärmeströmung im Untergrund hinsichtlich ihrer geothermischen Nutzung zu verstehen
- die Verfahren zur Erhebung und Auswertung von Daten (Felddaten, Bohrdaten) zu verstehen, welche die relevanten geothermischen Parameter abschätzen bzw. erheben.
- Verfahren zur Nutzung der oberflächennahen und tiefen Geothermie zu verstehen.
- Berechnungsmethoden zur Auslegung und Planung oberflächennaher Systeme anzuwenden, die Ergebnisse zu analysieren und zu bewerten.
- die Unsicherheiten und Risiken (z. B. Fündigkeits- und Bohrrisiken) in der Geothermie zu verstehen.

### **Teaching and Learning Methods:**

Das zu Grunde liegende Konzept des Moduls ist das problembasierte Lernen. Der Kern des Moduls besteht aus Lehrgesprächen mit Präsentationen zur Nutzung der tiefen und oberflächennahen Geothermie. Anschließend werden die Lerninhalte durch Übungen umgesetzt und vertieft werden. Die Übungen beinhalten Aufgaben zur Planung und Auslegung geothermischer Systeme und zum Verständnis der relevanten geologisch-thermischen Prozesse in der Geothermie. Hierbei werden Aufgaben gestellt, welche die Studierenden in selbstständiger Arbeitsweise analysieren sollen. Die Ergebnisse der Studierenden werden in der Gruppe diskutiert und der Lösungsweg aufgezeigt. Die Ergebnisse der Übungen werden den Studierenden auf der e-learning Plattform zur Verfügung gestellt um den Lösungsweg in der Nachbearbeitung überprüfen zu können. Die Vorlesung und Übung wird nach Bedarf und Möglichkeit durch Gastdozenten aus der Praxis unterstützt.

### **Media:**

Moodle e learning Plattform, wiki-Plattform, Power-Point Präsentationen, Übungsaufgaben am PC, Lehrgespräche, Diskussion, Gruppenarbeit

### **Reading List:**

BANKS, D. (2012): An Introduction to Thermogeology. – Ground source heating and cooling. 2nd Edition, 526 S., Wiley-Blackwell, Sussex.

DIPIPO, R. (2012): Geothermal Power Plants. – Principles, Applications, Case studies and Environmental Impact. – 600 S., Elsevier, Amsterdam.

GRANT, M. A. & BIXLEY, P. F. (2011): Geothermal Reservoir engineering. 2nd Edition, 359 S., Academic Press , Burlington.



HUENGES, E. (2010): Geothermal Energy Systems: Exploration, Development, and Utilization. - 463 S., Wiley VCH, Weinheim.

KALTSCHMIT, M., HUENGES, E. & WOLFF, H. [Hrsg.] (1999): Energie aus Erdwärme. – 265 S., Spektrum, Heidelberg.

KOENIGSDORFF, R. (2011): Oberflächennahe Geothermie für Gebäude. – 332 S., Fraunhofer IRB, Stuttgart.

OCHSNER, K. (2007): Geothermal Heat Pumps – A Guide for Planning and Installing. – 224 S., Cromwell Press, Trowbridge.

THOLEN, M. & WALTER-HERTKORN, S. (2008): Arbeitshilfen Geothermie. – 228 S., WVGW, Bonn.

**Responsible for Module:**

Kai Zosseder, [kai.zosseder@tum.de](mailto:kai.zosseder@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Einführung in die oberflächennahe und tiefe Geothermie (Vorlesung mit integrierten Übungen, 3 SWS)

Zoßeder K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU66030: Hydrogeological and Isotopic Methods for the Characterization of Groundwater Systems for Environmental Engineers | Hydrogeologische und Isotopenchemische Methoden zur Charakterisierung von Grundwassersystemen für Umweltingenieure**

Version of module description: Gültig ab winterterm 2016/17

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>90          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Die Prüfungsleistung (Feldkurs) besteht aus einer Laborleistung, die eine konkrete Auswertung der im Gelände durchgeführten hydraulischen Versuche, wasserchemischen Untersuchungen, Stichtagsmessungen und Vermessung von Grundwassermessstellen beinhaltet. Eine erste Auswertung der Versuche erfolgt am jeweiligen Abend nach der Geländearbeit und am letzten Kurstag unter Anleitung der Dozenten. Die Ergebnisse werden in einem schriftlichen Bericht (10-15 Seiten) von den Studierenden festgehalten.

Mit der Laborleistung wird so überprüft, inwieweit die Studierenden in der Lage sind, die erlernten hydrogeologischen Standardmethoden im Gelände anzuwenden, auszuwerten, zu beschreiben und die Ergebnisse zu interpretieren. Es wird geprüft, ob die Auswertung fachlich richtig und die daraus gefolgerten Schlüsse in verständlicher Form dargestellt wurden.

Zudem wird eine 60 minütige Klausur für die Isotopenhydrogeologie verlangt. Dabei wird zunächst überprüft, ob die Studierenden in der Lage sind, die in der Vorlesung erlernten theoretischen Grundlagen der Isotopenfraktionierung auf verschiedene Elemente des Periodensystems (S, N, H, O, C) anzuwenden. Zudem müssen die Studierenden anhand von Beispielen aus der Praxis ihre Fähigkeit unter Beweis stellen, dass sie Isotopendaten in einem geologisch/ hydrogeologischen Kontext interpretieren und (bio)geochemische Prozesse und Wasser/ Gesteinswechselwirkungen in Hoch- und Niedertemperatursystemen mithilfe der Isotopen für ein Einzugsgebiet bzw. ein Grundwassersystem interpretieren und ähnlich einem Kurzgutachten in Kurzform darstellen können. Darüber hinaus sollen die Studierenden die hydrogeologischen Charakteristika eines Einzugsgebietes mit Hilfe stabiler und radioaktiver Isotope beschreiben und den biotischen und abiotischen Abbau von Grundwasserverunreinigungen analysieren und die Ergebnisse in verständlicher, schriftlicher Kurzform darstellen können.

Hilfsmittel: Taschenrechner.

## **Repeat Examination:**

Next semester

## **(Recommended) Prerequisites:**

Empfohlen sind Kenntnisse der Hydrogeologie, sowie der Mathematik, Physik und Chemie. Teilnehmer/Innen sollten an der praktischen Arbeit im Gelände interessiert sein. Empfohlene Lehrveranstaltungen im Vorfeld sind die Kurse Grundwasserhydraulik (BGU66022).

## **Content:**

In diesem Modul werden die Studenten mit wichtigen Methoden der Hydrogeologie vertraut gemacht, die es erlauben ein Einzugsgebiet hydraulisch und isotopenchemisch (Herkunft der Wässer) zu charakterisieren.

Feldkurs:

- Einführung in die regionale Geologie/Hydrogeologie Niederbayerns
- Einführung in die hydrogeologische Geländearbeit
- Einmessen von Bohrungen/Grundwassermessstellen (Nivellierung),
- Lichtlotmessungen zur Erstellung eines Grundwasser-Gleichenplans,
- Durchführung und Auswertung von Pumpversuchen,
- Durchführung und Auswertung von Slug/Bail Versuchen,
- Durchführung und Auswertung von Abflussmessungen (Flügelmessung)
- Tracerversuch (Salztracermethode),
- Wasserchemische Untersuchungen im Gelände (mittels Sonden und Photometer) und Auswertung von Labordaten,
- Bodendurchlässigkeitsprüfung (Versickerungsversuch mit Guelph-Gerät)

Isotopenkurs:

- Was sind Isotope
- Wasserisotope in der Hydrogeologie
- Der S, N und C Kreislauf
- Nahrungsketten
- Grundwasserdatierung
- Fluid-Gesteins-Interaktion: Tiefenwässer und geothermische Wässer
- Komponentenspezifische Isotopenanalytik (CSIA)

## **Intended Learning Outcomes:**

Nach der Teilnahme an der Veranstaltung sind die Studierenden in der Lage:

- die genannten hydrogeologischen Standardmethoden im Feld anzuwenden, auszuwerten und unter Einbezug der Geologie zu interpretieren.
- die Isotopenchemie als zusätzliches „Cutting-edge“ Werkzeug für die Interpretation von komplexen hydrogeologischen Fragestellungen in Einzugsgebieten einzusetzen
- die theoretischen Grundlagen der Isotopenfraktionierung auf ausgewählte Elemente des Periodensystems anzuwenden
- die Labormethoden für die Analyse von Umweltisotopen zu beschreiben.

- Wasserisotopendaten aus Oberflächen- und Grundwasserleitern wissenschaftlich zu interpretieren
- biogeochemische Prozesse mit Hilfe der stabilen Isotope zu interpretieren und zu analysieren
- mit Hilfe von Isotopendaten einen Grundwasserleiter hydrogeologisch zu beschreiben und den Schadstoffabbau an kontaminierten Standorten qualitativ und quantitativ zu bewerten

### **Teaching and Learning Methods:**

Die Veranstaltung (Feldkurs) wird als Blockkurs über eine Woche in Niederbayern abgehalten. Die Studierenden werden zuerst interaktiv einbezogen, indem sie selbst die Hintergrundrecherchen zu den jeweiligen Versuchen und dem Standort durchführen und eine Kurzpräsentation dazu vorbereiten. In den Einführungsvorträgen (10 min.) stellen die Studenten die einzelnen Feldversuche vor. In Gruppen von bis zu 6 Studierenden bauen die Studenten unter Anleitung eines Dozenten den jeweiligen Versuch im Gelände auf und führen diesen unter Anleitung des Dozenten durch. Die einzelnen Gruppen durchlaufen während der Kurswoche die einzelnen Stationen. Am letzten Kurstag steht den Studierenden zur weiteren Auswertung der Computerraum der TUM mit entsprechender Auswertungssoftware zur Verfügung. Die Dozenten des Kurses diskutieren dort mit den Studierenden die Felddaten und unterstützen die Studenten bei der Auswertung ihrer Daten. Die Auswertung und ein Bericht mit der Beschreibung der Versuchsaufbauten wird in Form einer Projektarbeit von ca. 10-15 Seiten zusammengefasst. Die Veranstaltung zur Isotopenhydrogeologie besteht aus Vorlesungen und Übungen, wobei durch aktuelle Fallbeispiele ein problembasiertes Lernen mit unmittelbarem wissenschaftlichem und technischem Praxisbezug gewährleistet wird. Hier werden in Einzel- als auch in Gruppenarbeit Fallbeispiele gelöst und anschließend diskutiert. Dabei profitieren die Studenten v.a. durch die am Lehrstuhl bereits auf diesem Gebiet durchgeführten Projekte und den Erfahrungsschatz der Dozenten.

### **Media:**

Medienform:

e-Learning-Plattform Moodle, Präsentationen im Gelände (ohne Videoprojektor und Computer), Übungsaufgaben händisch und am PC, Lehrgespräche, Diskussion, praktische Arbeit im Gelände.

### **Reading List:**

FETTER (2001): Applied Hydrogeology. New Jersey (Prentice-Hall).

Clark & Fritz (1997): Environmental Isotopes in Hydrogeology. 398 S. Lewis Publisher

### **Responsible for Module:**

Dr. Anja Wunderlich, [anja.wunderlich@tum.de](mailto:anja.wunderlich@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Isotopenhydrogeologie (Vorlesung, 2 SWS)

Einsiedl F [L], Einsiedl F, Gilg H

Hydrogeologische Methoden – Geländetage (Übung, 3,5 SWS)

Wunderlich A [L], Baumann T, Rein A, Wunderlich A, Zoßeder K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66040: Case Studies in Technical Hydrogeology for Environ. Eng. | Technische Hydrogeologie in der Praxis für UI [TechHydroCaseEE]

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a project work with concluding presentation. The students will complete a project, containing the analysis of given hydrogeological problems and related tasks. The project work will be done in groups. During the project the students will take part in a simulation game which covers all phases of a hydrogeological site development (eg. hydrogeological aspects of a sustainable development of a business park). The assignments and presentations during the project are organized into initial offer in the simulated bidding procedure (5-8 pages, not graded), development of a sustainable concept for the business park (15 pages, 35%), detailed planning of site development (25 pages, 50%), presentation of results (oral, 15%)

The students demonstrate their ability to analyse and evaluate common technical issues in the fields of groundwater development, landfill technology, contaminated site investigation and remediation. The students demonstrate both their theoretical knowledge in technical hydrogeology and their ability to clearly present and visualise technical issues in hydrogeology. In particular, it can be examined to what extent the students are able to create solutions to real world hydrogeological problems and present their knowledge and skills orally, precisely and in a structured manner.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge of geology and hydrogeology, as well as mathematics, physics and chemistry are recommended. Participants.

+ Hydrogeology I (BGU66020 from the bachelor's programme in geosciences) or comparable content for external students

+ Module BV660002 Flow and Transport

### **Content:**

Students acquire the necessary knowledge and skills to recognize, describe, and solve technical problems in hydrogeology. The topics include:

- + Construction, operation and regeneration of groundwater catchments
- + Interpretation of camera logs of groundwater wells
- + Drinking water protection areas (basics, field work, design procedures, application documents, determination of protected areas, cooperation between engineering offices and authorities etc.)
- + Construction, operation and rehabilitation of landfills
- + Impacts of technical groundwater use (near-surface geothermal energy, irrigation and dewatering, storage systems)
- + Groundwater/surface water interactions
- + Legal framework for the treatment of contaminated sites
- + Definition of the impact pathways soil, groundwater, plant, human
- + Certification possibilities in practice
- + Investigation of groundwater contamination (historical investigation, preliminary and detailed investigation)
- + Examples from the practice of contaminated site investigation and remediation
- + Vulnerability of groundwater
- + security measures
- + Remediation procedures for groundwater contamination (encapsulation, in situ remediation, natural attenuation)
- + Remediation procedures for soil contamination
- + Remediation of multiple contaminations: The major ecological projects
- + Preparation of hydrogeological expertises (research question, concept development, data collection, hydrogeological model, preparation of expertises)

### **Intended Learning Outcomes:**

After participating in the module, students are able to apply and implement the theoretical principles and methods of technical hydrogeology in practice. In particular, they will be able to understand the basics and methods of hydrogeology:

- plan a well drilling and to supervise the construction technically and scientifically,
- to detect damage to well structures and develop proposals for solutions,
- apply the technical requirements for the construction and operation of landfills,
- to assess the impact of groundwater uses,
- to detect, investigate and remediate contaminated sites and aquifers,
- to understand the work flow in hydrogeological engineering offices, and to evaluate certification measures in professional practice,
- to analyse interdisciplinary topics and problems and find suitable solutions and to combine theoretical basics with practice-relevant expert knowledge.

### **Teaching and Learning Methods:**

The module consists of a lecture and a lecture with integrated exercises. The underlying concept of the module is problem-based learning. The core of the module consists of teaching discussions with presentations, which are implemented and deepened by integrated exercises and e-learning

elements. Using practical examples, the students work out solutions for typical hydrogeological problems in both complementary courses. In the course, both classical analogue methods (maps, log recordings, analysis reports) and modern digital methods on the PC are used. The practical relevance and implementation is conveyed through short excursions and site visits.

**Media:**

Lecture, group work on case studies, presentation of literature studies, videos of case studies, excursion, calculation and computer exercises, discussion, simulation games.

**Reading List:**

LANGGUTH & VOIGT (2004): Hydrogeologische Methoden.- Berlin (Springer).

FETTER (2018): Applied Hydrogeology.- (Waveland Press).

BIESKE, RUBBERT, TRESKATIS (1998): Bohrbrunnen.- (Oldenbourg).

HOUBEN, TRESKATIS (2007): Water Well Rehabilitation and Reconstruction.- (McGraw-Hill).

ELLIS, SINGER (2007): Well logging for Earth Scientists.- Berlin (Springer).

FETTER (1993): Contaminant Hydrogeology.- (Prentice-Hall).

DOMENICO, SCHWARTZ (1998): Physical and chemical hydrogeology.- (Wiley).

APPELO, POSTMA (2006): Geochemistry, groundwater and pollution.- Leiden (Balkema).

HOLZBECHER, E. (1996): Modellierung dynamischer Prozesse in der Hydrologie - Grundwasser und ungesättigte Zone.- 364 S.; Springer, Berlin.

SCHWARZENBACH, R. P, GSCHWEND, P. M. & IMBODEN, D. M. (2002): Environmental Organic Chemistry. 2.Aufl., Wiley, New York.

**Responsible for Module:**

Prof. Dr. Thomas Baumann (tbaumann@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Technische Hydrogeologie (Vorlesung, 2 SWS)

Baumann T

Hydrogeologie in der Praxis (Vorlesung mit integrierten Übungen, 2 SWS)

Zoßeder K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU66041: Contaminant Transport and Remediation | Transport und Sanierung von Schadstoffen [ContTransRemed]

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

At the end of the module, students participate in a written exam of 120 minutes duration. The exam will focus on the physical and chemical processes underlying contaminant transport and environmental remediation strategies and on the development of related computer models. The exam will verify that the students understand the principles to plan and carry out remediation of contaminated soils and water bodies. Furthermore, it will verify that the students understand basic concepts of environmental chemistry and pollutant transport in the environment and that the students are able to apply those concepts for the solution of problems within a given period of time. The exam will consist of open questions, multiple choice questions and exercises which will require short computations. In knowledge and transfer questions, the students demonstrate both their theoretical knowledge in pollutant hydrogeology and their ability to interpret and evaluate scientific measurement results quantitatively, to develop a prediction for mass dispersion in given exemplary scenarios and to clearly present and visualise the results, e.g. in schematic sketches and cross sections. No auxiliary material is allowed during the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in hydrology, hydrogeology and environmental chemistry (e.g., the MSc module Case studies in technical hydrogeology)

#### Content:

Students acquire the necessary knowledge and skills to quantitatively describe and evaluate the transport of pollutants in groundwater.

- Legal bases for the quality of groundwater and surface water

- Transport of water constituents in saturated and unsaturated environments (dispersion, sorption, degradation)
- Multiphase flow,
- Reactive mixing in surface water bodies
- Colloid transport,
- Transport properties of inorganic and organic contaminants
- General introduction on fate and transport of contaminants in the environment
- Analytical and numerical modeling of reactive solute transport
- Principles of in situ chemical oxidation
- Remediation technology for the unsaturated zone
- Land management

### **Intended Learning Outcomes:**

After participating in the module, the students are able to

- to quantify the spread of pollutants in groundwater and assess the risk of groundwater contaminations in a pollutant-specific way.
- to understand the effects of technical measures (e.g. iron removal, hardening, chlorination) in water treatment on the behaviour of pollutants and to transfer this knowledge to other issues (e.g. mixing of near-surface groundwater with deep groundwater)
- to understand the basic processes controlling commonly applied environmental remediation strategies
- to predict the effectiveness of different remediation strategies

The main objective of the moodle based modeling exercises is to enable students to understand, apply and further develop models to plan, predict and carry on remediation actions.

### **Teaching and Learning Methods:**

The module consists of two lectures. The teaching philosophy behind this module is based on the evidence that different study goals will be achieved using different approaches. The theoretical lectures' contents are presented by the lecturer using both the blackboard and digital slides. The students will get familiar with the subject solving independently relevant practical problems. Additionally, modelling exercises are offered on Moodle (asynchronous), with which the students train their programming skills

### **Media:**

Presentations (beamer/blackboard) , case studies in teams, excercise on e-learning platform

### **Reading List:**

- Kitanidis, P. K. and McCarty, P.L. (2012), Delivery and mixing in the subsurface: Processes and Design Principles for in situ remediation
- Siegrist et al. (2011), In Situ chemical oxidation for groundwater remediation
- Schoor J.L. (1996), Enviromental Modeling fate and transport of pollutants in water, air and soil
- Appelo C.A.J, Postma, D. (2006) Geochemistry, Groundwater and Pollution, Balkema,Leiden.
- Clark & Fritz (1997): Environmental Isotopes in Hydrogeology.-398 S. Lewis Publisher.
- Domenico, Schwartz(1998): Physical and chemical hydrogeology.- (Wiley).

Fetter (2001): Applied Hydrogeology.- New Jersey (Prentice-Hall).

Fetter, Boving, Kreamer (1998): Contaminant Hydrogeology, Long Grove (Waveland Press)

Matthess, G. (1994): Die Beschaffenheit des Grundwassers.- 499 S.; Berlin

**Responsible for Module:**

Prof. Dr. Thomas Baumann

**Courses (Type of course, Weekly hours per semester), Instructor:**

Transport von Schadstoffen im Grundwasser (Vorlesung, 2 SWS)

Baumann T

Environmental Remediation Strategies (Vorlesung, 2 SWS)

Chiogna G [L], Chiogna G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66042: Technical Aspects of Deep Geothermal Energy | Technische Aspekte der tiefen geothermischen Energie [TechGeothermal]

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

At the end of the module, students participate in a written exam of 90 minutes duration. In the exam (aid: pocket calculator) the students show their ability to analyse and evaluate practical problems of hydrochemical problems in geothermal energy. The focus is on the description of rock-water interactions, solution and precipitation processes and their avoidance. In knowledge and transfer questions, students demonstrate both their theoretical knowledge of hydrogeochemistry and their ability to interpret and evaluate scientific measurement results quantitatively, to develop proposals for solutions to hydrogeochemical problems in the development and operation of deep geothermal plants in given exemplary scenarios, and to clearly present and visualise the results, e.g. in schematic sketches and process diagrams. They demonstrate their ability to characterize, estimate and calculate hydraulic and mechanical properties of georeservoirs, in particular with application to deep geothermal drilling, reservoir stimulation and characterization of fractured and fault bounded reservoirs (petrothermal and enhanced geothermal systems).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Hydrochemistry (BGU66035)

Basic knowledge in geology

#### Content:

Students acquire the necessary knowledge and skills to recognize, describe, and solve technical problems in deep geothermal energy. The topics include:

Georeservoirs

- Basin fluids and basin analysis
- Origin and petrophysics of clastic, carbonate and crystalline reservoirs

- Fractured reservoirs and fault-related reservoirs
- Analysis of subsurface pressures and stresses
- Relevant mechanical properties
- Well planning and data acquisition
- Reservoir stimulation

#### Hydrochemistry

- Hydrogeochemical properties of typical deep aquifers
- lime-carbonic acid equilibrium
- Laws on the solubility of gases in water
- Hydrogeochemical processes
- Hydrogeochemical investigation program for characterization and design of deep geothermal plants
- Validation of hydrochemical analyses
- Interpretation of monitoring data
- Effects of solubility of trace gases on hydrochemical equilibria
- Calculation of the composition of deep waters and gas phases from analysis data
- Calculation of the partial pressures of gases in thermal water.
- Calculation and evaluation of potential precipitations when the degassing pressure is undershot.
- Conditioning of deep ground water to prevent precipitation and corrosion
- Long-term development of a geothermal doublet

#### **Intended Learning Outcomes:**

After successful participation of this module the students

- are able to identify and characterize the most important reservoir types and their hydraulic and mechanical properties
- are able to plan and scientifically supervise the drilling of deep wells and give recommendations for drilling targets
- have knowledge about different stimulation techniques and their potentials and risks
- know the hydrogeochemical properties of typical deep aquifers and the essential hydrogeochemical processes and are able to plan, carry out and supervise the hydrogeochemical investigation programme for the characterisation and design of deep geothermal plants in practice.
- are able to quantitatively calculate and predict hydrogeochemical processes along the entire geothermal cycle and evaluate the effects of technical measures (pressure maintenance, acidification, ...) in the geothermal cycle.
- are able to predict the long-term development of a geothermal system (doublet, triplet, multilateral)

#### **Teaching and Learning Methods:**

The module consists of two lectures with integrated exercises, which include slide shows, videos, quizzes, and exercises. The module also includes case studies and simulation games based on real world examples, where the students can directly apply the newly acquired theoretical background. The students develop proposals for solutions to individual problems and present them. Current topics (e.g. heat storage, fracking) are scientifically prepared in discussion formats (pro/contra).

**Media:**

Moodle e-learning platform, presentations, software based exercises, case studies (as teamwork), videos, discussions

**Reading List:**

Zoback, M.D. (2010): Reservoir Geomechanics (Cambridge University Press)  
Stober, I.; Bucher, K. (2013): Geothermal Energy – From theoretical models to exploration and development (Springer)  
Appelo, C.A.J. & Postma, D. (2005): Geochemistry, groundwater and pollution, 2nd edition.- Amsterdam (Balkema)  
Carlé, W. (1975): Die Thermal- und Mineralwässer von Mitteleuropa. Geologie, Chemismus, Genese. Stuttgart (Wiss. Verlagsges.)  
Parkhurst, D. & Appelo, C.A.J. (2014): Description of Input and Examples for PHREEQC Version 3 - A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations. U.S. Geological Survey Techniques and Methods, book 6, chap. A43. <http://pubs.usgs.gov/tm/06/a43/>  
Parkhurst, D. & Appelo, C.A.J. (2014): PHREEQC (Version 3) - A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations. U.S. Geological Survey. [http://wwwbrr.cr.usgs.gov/projects/GWC\\_coupled/phreeqc/](http://wwwbrr.cr.usgs.gov/projects/GWC_coupled/phreeqc/)  
Reimann, C. & Birke, M. (2010): Geochemistry of European Bottled Water. Stuttgart (Borntraeger)

**Responsible for Module:**

Prof. Dr. Thomas Baumann

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrochemie, Korrosion und Scalings (Vorlesung mit integrierten Übungen, 2 SWS)  
Baumann T

Georeservoir I (Vorlesung mit integrierten Übungen, 2 SWS)

Drews M, Duschl F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV150050: Environmental Geology / Geochemistry | Umweltgeologie / Geochemie

Version of module description: Gültig ab summerterm 2011

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>75   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Prüfungsdauer (in min.): 60.

schriftliche Prüfung

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Basics of geology; organic and inorganic chemistry

#### Content:

- Formation of elements and chemical composition of the crust and igneous rocks
- Aqueous solubility, weathering and geochemistry of natural waters
- geochemical effects of natural colloids
- acid mine/rock drainage, microbial processes, and remediation
- use of stable and radiogenic isotopes in environmental research
- environmental radioactivity
- origin, transport and biological uptake of toxic organic compounds
- particulates, mineral dusts, air pollutants, greenhouse gases, paleoclimate and carbon storage

#### Intended Learning Outcomes:

At the end of the module students are able

- to remember inorganic and organic natural and anthropogenic pollutants
- to understand the basic principles and processes related to distribution, transport and attenuation of hazardous elements in natural environments
- to design and assess isotope studies in environmental problems
- to evaluate the environmental risk of ores and mining wastes and plan remediation concepts

**Teaching and Learning Methods:**

The module is principally a lecture with power point presentations and black board writing. Important working materials such as figures and tables are accessible on-line. For a better learning outcome instructive demonstration materials (rock samples) are shown and given to the students. Some exercises are presented for homework.

**Media:**

powerpoint presentation; geological hands-on samples for illustration; handouts with important figures and tables

**Reading List:**

EBY GN (2003) Principles of Environmental Geochemistry, Brooks Cole.

SHERWOOD LOLLAR B (2005) Environmental Geochemistry (Treatise on Geochemistry, Vol.9), Elsevier.

LANGMUIR D (1997) Aqueous Environmental Geochemistry, Prentice Hall.

**Responsible for Module:**

Kurosch Thuro (Thuro@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Environmental Geology / Geochemistry (Vorlesung, 2 SWS)

Gilg H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV490057: Technical Hydrogeology | Technische Hydrogeologie

Version of module description: Gültig ab winterterm 2011/12

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Prüfungsleistung: In der schriftlichen Prüfung (Hilfsmittel Taschenrechner) zeigen die Studierenden ihre Fertigkeit zur problemlösungsorientierten Analyse und Bewertung gängiger technischer Fragestellungen aus den Themenfeldern Grundwassererschließung, Deponietechnik, Altlasterkundung und Altlastsanierung. Die Studierenden stellen sowohl ihr theoretisches Wissen in der technischen Hydrogeologie unter Beweis als auch die Fähigkeit, technische Sachverhalte in der Hydrogeologie anschaulich darzustellen und zu visualisieren. Bei weniger als 4 Prüfungskandidaten werden die Kompetenzen in gleicher Weise mündlich geprüft. Hierbei kann insbesondere überprüft werden, inwieweit die Studierenden in der Lage sind, ihr Wissen und ihre Fertigkeiten auch mündlich, präzise und strukturiert darzustellen und mit rhetorischer Sicherheit aufzutreten.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Modul P-09 Hydrogeologische Methoden

Modul P-10 Strömung und Transport

Modul W-10 Hydrochemie

#### Content:

This module introduces students to technical aspects of hydrogeology. Students will learn how to design, build and test ground water wells and waste disposals and to assess groundwater contaminations. Students will also learn how to conduct groundwater and soil remediation.

**Intended Learning Outcomes:**

Nach der Teilnahme an den Modulveranstaltungen sind die Studierenden in der Lage die theoretischen Grundlagen und Methoden der technischen Hydrogeologie in der Praxis

anzuwenden und umzusetzen. Sie verstehen insbesondere die Grundlagen und Methoden um:

- + eine Brunnenbohrung zu planen und die Erstellung technisch/wissenschaftlich zu überwachen
- + Schäden an Brunnenbauwerken zu erkennen und Lösungsvorschläge zu entwickeln,
- + die technischen Anforderungen an die Errichtung und den Betrieb von Deponien anzuwenden,
- + die Auswirkung von Grundwassernutzungen zu bewerten
- + kontaminierte Grundwasserleiter zu erkennen,
- + die Untersuchung von kontaminierten Standorten zu planen,
- + die Untersuchung von kontaminierten Standorten technisch und wissenschaftlich zu überwachen.
- + Vorschläge für die Sanierung kontaminierter Standorte zu planen,
- + Sanierungsvarianten zu bewerten.

**Teaching and Learning Methods:**

Vorlesung, Lehrgespräch, Gruppenarbeit an Fallbeispielen, Auswertung von Videoaufnahmen und geophysikalischen Bohrlochmessungen

**Media:**

Vortrag, Gruppenarbeit an Fallstudien, Präsentation von Literaturstudien, Videos von Fallbeispielen, Exkursion

**Reading List:**

LANGGUTH & VOIGT (2004): Hydrogeologische Methoden.- Berlin (Springer).

FETTER (2001): Applied Hydrogeology.- (Prentice-Hall).

BIESKE, RUBBERT, TRESKATIS (1998): Bohrbrunnen.- (Oldenbourg).

HOUBEN, TRESKATIS (2007): Water Well Rehabilitation and Reconstruction.- (McGraw-Hill).

ELLIS, SINGER (2007): Well logging for Earth Scientists.- Berlin (Springer).

FETTER (1993): Contaminant Hydrogeology.- (Prentice-Hall).

DOMENICO, SCHWARTZ (1998): Physical and chemical hydrogeology.- (Wiley).

APELLO, POSTMA (2006): Geochemistry, groundwater and pollution.- Leiden (Balkema).

**Responsible for Module:**

Thomas Baumann (thomas.baumann@ch.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Technische Hydrogeologie (Vorlesung, 2 SWS)

Baumann T

Erkundung und Sanierung von Grundwasserschadensfällen (Vorlesung, 1 SWS)

Baumann T

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Field of Study 5: Modelling and Measurement of Flow and Transport | Vertiefung 5: Modelling and Measurement of Flow and Transport

### Required Modules | Pflichtmodule

### Module Description

#### BGU41020: Fluid Mechanics and Transport Mechanisms | Fluidmechanik und Transportmechanismen

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcomes are checked by a written exam (90 min.).

Within this exam the students show, that they are able to solve calculation problems applying the classical relations of fluid mechanics, e.g. application of the Navier-Stokes equations, momentum theorem or the law of the wall in turbulent boundary layers.

Furthermore the students proof, that they are able - using given physical or fluid mechanical systems - to determine a set of similarity numbers and the describing time scales, to characterize transport phenomena in turbulent flows, apply boundary conditions to momentum and mass transport problems, estimate in an engineering manner the distribution of pollutants for different emission and transport scenarios and evaluation propagation processes in atmosphere and free surface flows.

Allowed aids are a handwritten A4 sheet (front and back) and a non-programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- module Hydromechanics (BV00013) or equivalent
- knowledge in vector and tensor calculus.

#### Content:

- continuum hypothesis

- calculus
- kinematics
- equations of motion in differential form
- scaling laws, time constants and dimensional analysis
- laminar and turbulent boundary layers
- repetition of the engineering fundamentals of fluid mechanics
- advection, diffusion and conservation equations
- propagation (diffusion and advection) of instantaneous and continuous point sources
- treatment and specification of boundary conditions
- closures for turbulent transport

### **Intended Learning Outcomes:**

On successful completion of this module the students are able to:

- explain the utilization of the concept of a continuum in fluid mechanics
- understand the concept and the structure of a (turbulent) boundary layer
- apply the Navier-Stokes equations for the incompressible case, the law of wall for turbulent flows to selected flow cases
- apply boundary conditions for momentum and mass transport problems
- characterize flow fields with the help of flow lines (stream lines, path lines, streak lines) and by the strain rate tensor and the rotation rate tensor
- characterize transport phenomena in turbulent flows
- determine a set of non-dimensional parameters for a given physical system
- determine the governing time constant of simple fluid mechanical systems and transport phenomena
- determine in an engineering manner the pollutant distributions for different emission and transport scenarios
- determine forces, pressure and velocities that act on the boundaries of a flow domain by means of simple tools within a short time
- evaluate propagation processes in atmosphere and free surface flows

### **Teaching and Learning Methods:**

The modul is based on a classical lecture. The main content is derived on the blackboard, supported by slides and discussed with students. Examples are shown to underline the importance and the applications of the discussed relations. Further the student are encouraged to research literature before and after classes to compare different ways of derivation and presentation. There is voluntary homework. This gives the students the chance to apply their knowledge to small problems and check their learning progress periodically during the semester. There is also a voluntary seminar (90min.) for the Fluid Mechanics part. There the students can solve the homework sheets in small groups and post-process the lecture. The discussion of the students is moderated and supported by a lecturer.

### **Media:**

black / white board, presentation slides, videos, exercise sheets, e-learning

**Reading List:**

- Course script, presentations and assignments available to participants on elearning platform

G. K. Batchelor. An Introduction to Fluid Dynamics. Cambridge University Press, 1967.

I. G. Currie. Fundamental Mechanics of Fluids. McGraw-Hill, New York, 1974.

P. K. Kundu and I. M. Cohen. Fluid Mechanics, Third Edition. Elsevier, Amsterdam, 2004.

R. L. Panton. Incompressible flow. John Wiley and Sons, Inc, Hoboken, third edition, 2005.

D. J. Tritton. Physical Fluid Dynamics. Van Nostrand Reinhold, New York, 1977.

M. van Dyke. An Album of Fluid Motion. Parabolic Press, Stanford, California, 1982.

S. B. Pope. Turbulent flows. Cambridge University Press, Cambridge, 2000.

H. Tennekes and J. L. Lumley. A first course in turbulence. The MIT Press, Cambridge, Massachusetts, 1972.

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Fluid Mechanics and Transport Mechanisms (Vorlesung, 4 SWS)

Manhart M, Sakai Y, Quosdorf D

Seminar zur Fluidmechanik (Seminar, 2 SWS)

Quosdorf D, Ungleht L, Brosda J, von Wenczowski S, Sakai Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54008T2: Hydrological and Environmental River Basin Modelling | Hydrologische und ökologische Flussgebietsmodellierung [HERBM]

Version of module description: Gültig ab winterterm 2013/14

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a 90 minute written exam and additional course work.

In the written exam, the students show that they have achieved the learning outcomes under pressure of time (knowing and understanding constituents of transport processes /cycles of matter and their numerical modelling). The exam consists of 1/3 theoretical questions and 2/3 calculations. Allowed tool is a non-programmable calculator.

The course work serves to assess the students' competence to apply an eco-hydrologic model and to process the simulation output data. Further the ability to analyze and present the results in a comprehensive way is tested.

During the exercises the students start the course work (e.g. model setup, methods to evaluate modelling results) and receive support by student tutors and the lecturing tutor. After they have received the final question for the course work, the students can continue working on it during the remaining exercises and during self-study hours in groups of 4 persons and have to prepare and hand in a written report (approx. 20 pages).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basics of hydrology and GIS

#### Content:

Different components of an eco-hydrological model and their interactions will be explained and their respective calculation methods will be presented:

- Climate data and snow
- Evapotranspiration
- Infiltration and soil water

- Surface runoff
- Groundwater
- Streamflow

Additionally, modelling of plant growth and associated water as well as nutrient demands are presented. Water quality aspects and the interplay with issues of land use and management practices are also brought up.

- Nutrients and nutrient transport
- Erosion
- Plant growth and management practices

Eco-hydrological modelling will be taught based on a practical example in the computer lab:

- Model setup in SWAT
- Carrying out simulations
- Evaluation of model results: data post-processing
- Evaluation of model results: interpretation of results and diagnosis
- Manual calibration

### **Intended Learning Outcomes:**

At the end of the module, the students are able to:

- understand how environmental processes (i.e. concerning the water cycle) are modelled in numerical eco-hydrological software model like SWAT.
- understand different methods for the calculation of single components of eco-hydrological cycles and their interplay.
- use an eco-hydrological model
- process the model results for evaluation
- identify different influencing factors on the model quality
- assess the meaningfulness of model results and
- present them in a comprehensive fashion in a final assessment report.

### **Teaching and Learning Methods:**

The module consists of a lecture and an exercise.

Lecture (talk, presentation, group work): The lecture provides the historical, mathematical and empirical basics for various modelling approaches to the different model components (e.g.: Green and Ampt in comparison with SCS-CN method to model infiltration). The underlying assumptions, characteristics (Which kind of behavior, observed in nature do we want to mimic? For instance the seasonal and sinusoidal oscillation of soil temperature and damping with depth), data requirements and limits of application are discussed. The lecture therefore aims at the first two study goals.

Exercises (talk, presentation, individual and group work, case study): A detailed investigation of single model components as it is done in the lecture is hardly possible for the practical application of the software. The interplay of model components (climate, soil, aquifers, runoff, sediments, plant growth) is often complex and non-linear over time. The application of a software model, the understanding of the interplay of its many components as well as the assessment of the results is taught and learned with hands-on exercises – computer lab and course work.



**Media:**

Lecture; PowerPoint presentations, black board, scientific papers,

Exercise: Script, Software: SWAT, ArcSWAT, SWATPlot, Excel, R, SWATCup, Technical Manuals

**Reading List:**

Neitsch, S., J. Arnold, J. Kiniry, and J. Williams (2011). Soil and water assessment tool- theoretical documentation version 2009. Report, Grassland, Soil and Water Research Laboratory - Agricultural Research Service, Blackland Research Center - Texas AgriLife Research.

Winchell, M., R. Srinivasan, M. diLuzio, and J. Arnold (2007). ArcSWAT Interface for SWAT2005 - Users Guide. [http://www.geology.wmich.edu/sultan/5350/Labs/ArcSWAT\\_](http://www.geology.wmich.edu/sultan/5350/Labs/ArcSWAT_Documentation.pdf)

Documentation.pdf: Blackland Research Center and Grassland, Soil and Water Research Laboratory (USDA Agricultural Research Service)

Arnold, J., J. Kiniry, R. Srinivasan, J. Williams, E. Haney, and S. Neitsch (2011). Soil and Water Assessment Tool- Input/Output File Documentation Version 2009. <http://swat.tamu.edu/media/19754/swat-io-2009.pdf>: Grassland, Soil and Water Research Laboratory Agricultural Research Service, Blackland Research Center Texas AgriLife Research.

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse ([markus.disse@tum.de](mailto:markus.disse@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrological and Environmental River Basin Modelling - Exercise (Übung, 2 SWS)

Disse M, Tuo Y

Hydrological and Environmental River Basin Modelling (Vorlesung, 2 SWS)

Disse M, Tuo Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Elective Modules | Wahlmodule

### Module Description

## BGU41019: Modeling and Simulation of Turbulent Flows | Modellierung und Simulation turbulenter Strömungen

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

### Description of Examination Method:

The module examination is a written exam.

The learning outcomes will be evaluated by a written exam (60 min., aids: one sheet of handwritten notes of format A4, calculator). The aim of the written exam is to proof, that the students understand the fundamentals and possible descriptions of turbulent flows and that they are able to apply the scaling laws. Further the students show that they are able, for a given flow problem, to judge which model or strategy for the description of turbulent flow suits best with respect to applicability and reliability and to estimate the calculation effort and accuracy.

### Repeat Examination:

Next semester

### (Recommended) Prerequisites:

- module Hydromechanics (BV00013) or equivalent
- module Fluid Mechanics and Groundwater Hydraulics (BGU41016) or Fluid Mechanics and Transport Mechanisms (BGU41020) or Advanced Fluid Mechanics (BGU41021), respectively

### Content:

- introduction to turbulent flow
- mechanisms of turbulence generation
- scaling laws and turbulent spectra
- simulation strategies for turbulent flows: direct numerical simulation (DNS), Reynolds-Averaged-Navier-Stokes (RANS), large-eddy simulation (LES)
- Reynolds averaged Navier-Stokes equations
- algebraic, one- and two equation models

- turbulent boundary layers, channel and pipe flow
- estimation of length scales and definition of a numerical grid
- estimation of time scales to simulate turbulent flows
- choice of suitable boundary conditions
- simulation of turbulent flow using an openSource code
- pre- and postprocessing
- comparison RANS-LES

### **Intended Learning Outcomes:**

On successful completion of this module the students are able to:

- describe the phenomenology of turbulent flow
- understand the description of turbulent flows by means of mean value and fluctuation
- use universal scaling laws of turbulent flow
- apply the modeling of turbulent flow in the context of Reynolds-averaging (RANS) as well as with the help of large-eddy simulation (LES)
- estimate the suitability of one of these methods to compute a given type of quantity in a turbulent flow, considering reliability, cost and reliability of modeling, computing time and accuracy
- generate a suitable grid
- plan, conduct and evaluate a simulation of a simple turbulent flow situation using Reynolds averaged Navier-Stokes equations
- estimate time scales for the simulation of a turbulent flow

### **Teaching and Learning Methods:**

The module consists of a lecture with an integrated exercise. During the lecture a mixture of derivations on the blackboard, slides, small examples and in-class discussions are used to teach the content. Within the integrated exercise various problems are solved using Matlab and a simple turbulent flow problem is simulated using an openSource code. Here the students solve the problems on their own in small groups, while the lecturer is in the room to support if needed.

### **Media:**

black / white board, presentation slides, videos, exercise sheets, e-learning, practical exercises using Matlab and OpenFoam

### **Reading List:**

M. van Dyke. An Album of Fluid Motion. Parabolic Press, Stanford, California, 1982.  
S. B. Pope. Turbulent flows. Cambridge University Press, Cambridge, 2000.  
H. Tennekes and J. L. Lumley. A first course in turbulence. The MIT Press, Cambridge, Massachusetts, 1972.

### **Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Modeling and Simulation of Turbulent Flows (Vorlesung mit integrierten Übungen, 4 SWS)

Manhart M, von Wenczowski S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU41029: CFD - Solution Methods of the Navier-Stokes Equations | CFD - Lösungsmethoden der Navier-Stokes-Gleichungen

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The final examination in this module is an oral examination. The oral exam is held in the form of a group presentation (3-5 students). This is followed by an individual discussion with the examiner. The total duration is 30 min. maximum. During this discussion, students demonstrate that they are able to identify suitable numerical methods for solving the Navier-Stokes equations and to implement it in a flow solver. They also show that they are able to evaluate the quality of the result of their own numerical simulation and to classify numerical effects in simple situations. Furthermore, the students show that they can present the core statements of the joint work and discuss them with specialists in the field using technical terms.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- module Fluid Mechanics and Ground Water Hydraulics (BGU41016) or Fluid Mechanics and Transport Mechanisms (BGU41020) or Advanced Fluid Mechanics (BGU41021), respectively
- module Numerical Methods in Hydromechanics (EE) (BGU41027)
- knowledge in Engineering Mathematics including linear algebra, differential calculus, integration, vector calculus and field theory
- basic knowledge in programming language Matlab

#### Content:

- solution of the Navier-Stokes equation
- pressure correction and solution of the Poisson equation
- analysis of numerical errors
- programming a two-dimensional solver for the incompressible Navier-Stokes-equations in Matlab

**Intended Learning Outcomes:**

After successfully passing this module, the students are able to:

- implement different solution methods to solve the Navier-Stokes equations for incompressible flows in a flow solver
- select suitable numerical methods for various classes of flow situations
- interpret results obtained by implementing different methods/schemes and their combination (time integration, spatial discretization) when solving the Navier-Stokes equation

**Teaching and Learning Methods:**

The teaching content is taught in a lecture with an integrated programming exercise.

In the lecture the basic terms, concepts and methods will be presented using the black board, presentations slides and examples.

In the computer exercise different numerical components of flow solvers will be implemented.

There the students solve programming exercises in groups on their own, being supported by the lecturer if needed. At the end the group work results are demonstrated in short presentations and discussed with the lecturer.

**Media:**

black/ white board, presentations, notes, script, eLearning, Matlab-code

**Reading List:**

- J.H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, 3rd Edition, Springer-Verlag, 2002.
- P. Moin, Fundamentals of Engineering Numerical Analysis, Cambridge University Press, 2001

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

CFD - Lösungsmethoden der Navier-Stokes-Gleichungen (Vorlesung mit integrierten Übungen, 2 SWS)

Sakai Y, Manhart M, Quosdorf D, von Wenczowski S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46030: Ecological Modeling of Surface Waters | Ökologische Modellierung für Oberflächengewässer [ANNA]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Der Leistungsnachweis wird durch eine schriftliche Prüfung (60 min) am Ende des Semesters erbracht, aus welcher sich die Note für das Modul ergibt.

Dabei soll nachgewiesen werden, dass die Studierenden die wesentlichen Aspekte der spezifischen Aufgabenstellung aus den Bereichen Gewässer / Strömungsvorgänge / Ökologie / Habitatmodellierung verstanden haben und anwenden können.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bachelor Degree in Civil or Environmental Engineering.

#### Content:

1. INTRODUCTION. Basic definitions. The significance of ecological models within the implementation of the Water Framework Directive (WFD) with examples.

2. CONCEPTS OF ECOLOGICAL MODELING FOR SURFACE WATERS. Components of an ecological model. Processes and their mathematical description. The main steps of the procedure of ecological modeling.

3. TYPES OF ECOLOGICAL MODELS. Overview of models with examples; advantages and disadvantages.

4. EXAMPLES OF SIMPLE ECOLOGICAL MODELS. Organic pollution in a river; eutrophication in a lake; habitat modeling in a river; and others. Exercises using EXCEL.

5. REAL LIFE APPLICATIONS.

**Intended Learning Outcomes:**

After successful completion of the course the students are able to (1) know the main characteristics of ecological models and their application, (2) realize the potential of application of ecological models as management tools, (3) understand the use of ecological models to deal with pollution problems and pressures within the implementation of the WFD, (4) develop simplified versions of these models using Excel, and (5) know how to apply computer codes for these models in real cases.

**Teaching and Learning Methods:**

The lectures are performed interactively with presentations and calculations. Real cases are presented in the classroom and are critically discussed with the students. There are 3 simple obligatory homework exercises that are given to the students. The students form groups of 2 and are expected to solve the exercises and turn them in; then, these are corrected and returned to them.

**Media:**

Presentations on the blackboard; Power Point presentations; calculations in PCs using Excel and computer codes.

**Reading List:**

1. Fath, B. and Jorgensen, S. E. (2011). Fundamentals of Ecological Modelling, Volume 23, Fourth Edition: Applications in Environmental Management and Research (Developments in Environmental Modelling), Elsevier; <http://www.ebooks-share.net/fundamentals-of-ecological-modelling-volume-23-fourth-edition-applications-in-environmental-management-and-research-developments-in-environmental/>.
2. European Commission European Commission (2012). Indicators and Methods for the Ecological Status Assessment: Linkages between Chemical and Biological Quality of Surface Waters, Joint research Centre; <http://www.amazon.de/Indicators-Methods-Ecological-Status-Assessment/dp/3845456914>.
3. Socolofsky, A. and Jirka, G. (2002). Environmental Fluid Mechanics, Part I: Mass Transfer and Diffusion, Lectures, Institute for Hydromechanics, KIT; [http://www.ifh.uni-karlsruhe.de/lehre/envflu\\_I/Course\\_script/course\\_script.htm](http://www.ifh.uni-karlsruhe.de/lehre/envflu_I/Course_script/course_script.htm).
4. Stamou, A. (2014). Ecological modeling of surface waters, TUM (in preparation).



**Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Ecological Modeling of Surface Waters (Vorlesung, 2 SWS)

Bui M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU46033: Laboratory and Field Exercises at the Oberrach Lab | Modelltechnische und flussbauliche Übungen an der Versuchsanstalt Oberrach [VAO\_2016]** *Block Course VAO*

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                             |
|--------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Discussion, presentation (information on individual knowledge level in group work, application of acquired knowledge to project examples), report, aids allowed

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basic and supplementary module hydraulic engineering and water management or corresponding Bachelor courses

#### **Content:**

Five-day block course + report

1 day theory: Fundamentals of hydraulic engineering modeling experiments, presentation of the current model tests in Oberrach.

4-day practice: Carrying out experiments on current hydraulic engineering models (measuring, documenting, evaluating and evaluating as well as presenting and discussing the results).

Detailed report on the model projects and the results obtained.

#### **Intended Learning Outcomes:**

After passing this course, students are able:

- to apply by means of practical work with running water in-depth hydrological knowledge to examples.
- to understand and successfully deal with questions of current hydraulic engineering projects.

**Teaching and Learning Methods:**

Lectures on the preparation of the necessary basics, guided tour through the experimental facilities with the current hydraulic engineering projects for the transfer of the basics to the practice, three-day group work in the laboratory for the practical experience, own presentation for the analysis and summary of the produced results, writing a detailed report.

Free accommodation in VAO's guest house for the duration of the course!

**Media:**

Lecture (90 min), 2-hour guided tour through the experimental halls in Oberrach, 3 days group work on hydraulic model experiments, 1 day presentation and discussion, writing a report.

**Reading List:****Responsible for Module:**

Arnd Hartlieb (arnd.hartlieb@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modelltechnische und flussbauliche Übungen an der Versuchsanstalt Oberrach (Übung, 3 SWS)

Hartlieb A [L], Hartlieb A, Scherbaum S, Schlagenhauser M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54013T2: Seminar in Rainfall-Runoff Modelling | Seminar Niederschlags-Abfluss Modellierung [SRRM]

Version of module description: Gültig ab winterterm 2014/15

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Total duration: 45 min.

- Presentation and discussion (30 min.)
- Oral exam (15 min.)

#### Repeat Examination:

#### (Recommended) Prerequisites:

Hydrological fundamentals,  
e.g. Grundmodul Hydrologie (Bachelor Umweltingenieurwesen, TUM)

#### Content:

The course contents are based on the book Rainfall-Runoff Modelling: "The Primer" by Keith Beven from Lancaster University:

The book provides a primer for the novice and detailed descriptions of techniques for more advanced practitioners. [&] It gives a comprehensive summary of available techniques based on established practices and recent research, [offering] a thorough and accessible overview of the area.

- 1.Runoff Processes and the Modelling Process
- 2.Evolution of Rainfall-Runoff Models
- 3.Data for Rainfall-Runoff Modelling
- 4.Predicting Hydrographs Using Models Based on Data

5. Predicting Hydrographs Using Distributed Models Based on Process Descriptions
  6. Hydrological Similarity, Distribution Functions and Semi-Distributed Rainfall Runoff Models
  7. Parameter Estimation and Predictive Uncertainty
  8. Models for Changing Risk
  9. Next Generation Hydrological Models
  10. Predictions in Ungauged Basins
  11. Water Sources and Residence Times in Catchments
  12. Hypotheses, Measurements and Models of Everywhere
- 

### **Intended Learning Outcomes:**

At the end of the module, students are able to:

- Know the theory of different types of rainfall-runoff models.
- Understand the concepts that underlie different modelling approaches.
- Evaluate models and critically assess the assumptions made.

Furthermore the students should learn to:

- Present a topic, as well as to facilitate and lead a discussion about it.
- 

### **Teaching and Learning Methods:**

The module consists of a seminar with an introductory lesson given by the lecturer. The students will form groups of two people and pick a topic they will present in the consecutive lessons. The activities comprise:

- Literature study
  - Summarizing and presenting a topic
  - Guiding and facilitating a discussion on the presented topic
  - Consecutive online tests
- 

### **Media:**

Powerpoint  
Blackboard

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### **Reading List:**

Beven, K. J. Rainfall-Runoff Modelling: The Primer. 2nd ed. Chichester, West Sussex/; Hoboken, NJ: Wiley-Blackwell, 2012.

AVAILABLE as .pdf download though the TUM library (eaccess login -> search in UB catalogue)

**Responsible for Module:**

Markus Disse (markus.disse@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Seminar in Rainfall-Runoff Modelling (Vorlesung, 2 SWS)

Disse M [L], Tuo Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54016: Process Based Modelling of Mesoscale Pre-alpine Catchments | Prozessbasierte Modellierung mesoskaliger voralpiner Einzugsgebiete [MPAC]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam consists of a project work to be presented both in written and oral form. The written report (30-40 pages long) is a group work on the theoretical background and the application of the two presented models including preprocessing, model generation and results. The results have to be presented to the class in an oral presentation (20 minutes presentation followed by a discussion). The written report and the oral presentation are equally weighted.

Auxiliary means are not allowed.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in hydrology and hydraulics

#### Content:

- 1) Dominant hydrological processes in pre-alpine catchments: Precipitation types and snow processes; runoff generation, concentration and flood routing
- 2) Data in small alpine catchments: availability, quality, acquisition and analysis
- 3) Types of hydrological and hydraulic models and applicability in pre-alpine catchments
- 4) Generation, parameterization and calibration of the process based hydrological model WaSiM
- 5) Model sensitivity analyses with focus on interpolation of the meteorological input, snow processes and runoff concentration
- 6) Process based modeling of the flood routing processes using the 2D-hydrodynamic-numerical model HYDRO\_AS-2D
- 7) Analysis of the water balance influenced by different land use and climatic boundaries

8) Quantification of the effectiveness of flood mitigation measures using the (coupled) modeling approach

**Intended Learning Outcomes:**

At the end of the module, students are able to understand the main processes in pre-alpine catchments like snow processes as well as runoff generation, runoff concentration and flood routing processes. Additionally, they are able to understand different methods for the calculation of these processes. Moreover, students are able to use a physically based hydrological model and a 2d hydrodynamic-numerical model to simulate the rainfall runoff process in pre-alpine catchments and its influencing parameters caused by the special circumstances of these regions in a widely realistic and transparent way. The students are able to generate event based scenarios as well as land use scenarios and based on this to evaluate different flood mitigation strategies for such regions.

**Teaching and Learning Methods:**

Lectures, block seminar and exercises

**Media:**

- PowerPoint presentations
- Technical manuals

**Reading List:**

DeWalle, D.R. & Rango, A. (2008): Principles of snow hydrology. Cambridge University Press, Cambridge and UK and New York.

Hydrotec Ingenieurgesellschaft mbH & M. Nujić (2014): Benutzerhandbuch HYDRO\_AS-2D - 2D-Strömungsmodell für die wasserwirtschaftliche Praxis. Aachen, November 2014

Schmocker-Fackel, P., Naef, F. & Scherrer, S. (2007). Identifying runoff processes on the plot and catchment scale, Hydrol. Earth Syst. Sci., 11, 891 - 906. [www.hydrol-earth-syst-sci.net/11/891/2007/](http://www.hydrol-earth-syst-sci.net/11/891/2007/).

Schulla, J. (2014): Model Description WaSiM: Water balance Simulation Model. Zürich.

Warscher, M., Strasser, U., Kraller, G., Marke, T., Franz, H. & Kunstmann, H. (2013): Performance of complex snow cover descriptions in a distributed hydrological model system: A case study for the high Alpine terrain of the Berchtesgaden Alps. In: Water resources research 49 (5), pp. 2619-2637.

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse

**Courses (Type of course, Weekly hours per semester), Instructor:**

Process based modelling of mesoscale pre-alpine catchments (Vorlesung, 4 SWS)



Disse M [L], Broich K, Disse M, Merk F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54026: Urban Flood Modelling | Modellierung städtischer Überschwemmungen [UFM]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

At the end of the module, students submit a report (10-15 pages) with corresponding presentation (circa 15 min). The report is a written record and summary of the three main exercises followed during the Module, covering the setup, application and analysis of the results from three different urban flood models (sewer network model, overland flow model and dual drainage flow model). The report will verify that the students understood the basic concepts of flood modelling in urban areas and that they were able to apply those concepts for the solution of problems within a given period of time. The students will work in groups of maximum of three. The presentation is also done in groups. The presentation will verify if the students are able to present their results in a coherent manner, discuss and answer questions related to urban flood modelling.

Prüfungsart

Report (10-15 pages)

Prüfungsdauer (in Minuten)

15 min presentation +10 min discussion

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Fundamentals of Hydrology (e.g. Hydrologie Grundmodul)
- Basic Knowledge of Sewer Drainage Systems (e.g. Siedlungswasserwirtschaft Grundmodul - Kanalisation)
- Basic Knowledge of Arc-Map

#### Content:

Introduction: Overview of the most important urban hydrological and hydraulic processes and concepts.

Challenges in urban flood modelling, in relation to flood management and flood risk assessment.

T1. Sewer drainage model I - SWMM model setup of Maxvorstadt (computational work).

T2. Sewer drainage model II - analysis of results (computational work).

Introduction to overland flood models in urban areas.

T3. Overland flow model I – P-DWave model setup of Maxvorstadt (computational work).

T4. Overland flow model II – analysis of results (computational work).

Introduction to dual drainage models.

T5. Dual drainage flow model I - P-DWave/SWMM setup of Maxvorstadt (computational work).

T6. Dual drainage flow model II - analysis of results (computational work).

Urban flood management: Sustainable Urban Drainage System (in Munich).

Discussion/Feedback on the report.

Presentation and discussion of the report.

Wrap-up.

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### **Intended Learning Outcomes:**

The students at the end of the module will be able to understand and analyse:

- the fundamental concepts of urban flood modelling,
- the need and usefulness of different model types
- the different types of Sustainable Urban Drainage Systems (SUDS)

Finally, the students are able to discuss the range of applicability as well as advantages and disadvantages of different UFM for different contexts, namely, flood risk and flood management, and for different densifications of urban areas

### **Teaching and Learning Methods:**

Lecture with integrated computational exercises. 3 computer exercises (each split in two parts).

The exercises can be done in group. Students submit a report (10–15 pages) summarizing their results. Students will receive feedback during the lectures on their reports. Students will prepare and present their reports during the lecture period

### **Media:**

Powerpoint, black-board, PDFs, teamwork followed by discussion

### **Reading List:**

### **Responsible for Module:**

Jorge Leandro, [jorge.leandro@tum.de](mailto:jorge.leandro@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Urban Flood Modelling (Vorlesung mit integrierten Übungen, 2 SWS)

Teixeira Leandro J [L], Teixeira Leandro J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66041: Contaminant Transport and Remediation | Transport und Sanierung von Schadstoffen [ContTransRemed]

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

At the end of the module, students participate in a written exam of 120 minutes duration. The exam will focus on the physical and chemical processes underlying contaminant transport and environmental remediation strategies and on the development of related computer models. The exam will verify that the students understand the principles to plan and carry out remediation of contaminated soils and water bodies. Furthermore, it will verify that the students understand basic concepts of environmental chemistry and pollutant transport in the environment and that the students are able to apply those concepts for the solution of problems within a given period of time. The exam will consist of open questions, multiple choice questions and exercises which will require short computations. In knowledge and transfer questions, the students demonstrate both their theoretical knowledge in pollutant hydrogeology and their ability to interpret and evaluate scientific measurement results quantitatively, to develop a prediction for mass dispersion in given exemplary scenarios and to clearly present and visualise the results, e.g. in schematic sketches and cross sections. No auxiliary material is allowed during the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in hydrology, hydrogeology and environmental chemistry (e.g., the MSc module Case studies in technical hydrogeology)

#### Content:

Students acquire the necessary knowledge and skills to quantitatively describe and evaluate the transport of pollutants in groundwater.

- Legal bases for the quality of groundwater and surface water

- Transport of water constituents in saturated and unsaturated environments (dispersion, sorption, degradation)
- Multiphase flow,
- Reactive mixing in surface water bodies
- Colloid transport,
- Transport properties of inorganic and organic contaminants
- General introduction on fate and transport of contaminants in the environment
- Analytical and numerical modeling of reactive solute transport
- Principles of in situ chemical oxidation
- Remediation technology for the unsaturated zone
- Land management

### **Intended Learning Outcomes:**

After participating in the module, the students are able to

- to quantify the spread of pollutants in groundwater and assess the risk of groundwater contaminations in a pollutant-specific way.
- to understand the effects of technical measures (e.g. iron removal, hardening, chlorination) in water treatment on the behaviour of pollutants and to transfer this knowledge to other issues (e.g. mixing of near-surface groundwater with deep groundwater)
- to understand the basic processes controlling commonly applied environmental remediation strategies
- to predict the effectiveness of different remediation strategies

The main objective of the moodle based modeling exercises is to enable students to understand, apply and further develop models to plan, predict and carry on remediation actions.

### **Teaching and Learning Methods:**

The module consists of two lectures. The teaching philosophy behind this module is based on the evidence that different study goals will be achieved using different approaches. The theoretical lectures' contents are presented by the lecturer using both the blackboard and digital slides. The students will get familiar with the subject solving independently relevant practical problems. Additionally, modelling exercises are offered on Moodle (asynchronous), with which the students train their programming skills

### **Media:**

Presentations (beamer/blackboard) , case studies in teams, excercise on e-learning platform

### **Reading List:**

- Kitanidis, P. K. and McCarty, P.L. (2012), Delivery and mixing in the subsurface: Processes and Design Principles for in situ remediation
- Siegrist et al. (2011), In Situ chemical oxidation for groundwater remediation
- Schoor J.L. (1996), Enviromental Modeling fate and transport of pollutants in water, air and soil
- Appelo C.A.J, Postma, D. (2006) Geochemistry, Groundwater and Pollution, Balkema,Leiden.
- Clark & Fritz (1997): Environmental Isotopes in Hydrogeology.-398 S. Lewis Publisher.
- Domenico, Schwartz(1998): Physical and chemical hydrogeology.- (Wiley).

Fetter (2001): Applied Hydrogeology.- New Jersey (Prentice-Hall).

Fetter, Boving, Kreamer (1998): Contaminant Hydrogeology, Long Grove (Waveland Press)

Matthess, G. (1994): Die Beschaffenheit des Grundwassers.- 499 S.; Berlin

**Responsible for Module:**

Prof. Dr. Thomas Baumann

**Courses (Type of course, Weekly hours per semester), Instructor:**

Transport von Schadstoffen im Grundwasser (Vorlesung, 2 SWS)

Baumann T

Environmental Remediation Strategies (Vorlesung, 2 SWS)

Chiogna G [L], Chiogna G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV410004: Fluid Mechanics Lab | Fluidmechanik Praktikum

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Performing the experiments in the lab are the ungraded course achievement of this module.

Writing a lab report on the experiments performed (50% of the modul grade) and giving a short presentation of the results (50% of the modul grade) are the graded part of this module.

While the experimental skills are tested performing the experiments the lab report examines the theoretical knowledge of the measurement methods and the capability to evaluate the information gained. The oral presentation (30 min.) shows that the students are able evaluate the results according to their reliability and the investigated flow situations in a coherent manner.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Prerequisite for this course is the successful completion of module Fluid Mechanics and Groundwater (BGU0410013) respectively Fluid Mechanics and Turbulence (BV410013)

#### Content:

- Light waves and their properties
- quantum-mechanical phenomena
- particle-light-interaction
- laser as a light source
- particle and particle dynamics
- introduction to statistics
- Laser Doppler Velocimetry
- Particle Image Velocimetry
- laser safety instruction
- practical exercise LDA
- practical exercise PIV

**Intended Learning Outcomes:**

After successful completion of this module the students are able to:

- explain the properties of light waves (reflection, refraction) and quantum-mechanical phenomena (absorption, emission)
- understand the concept and structure of a laser
- choose type of tracer particles depending on the measurement method (LDV, PIV), the measurement set up and the flow situation
- perform measurements using LDV and PIV
- analyse measurement results using certain statistical methods
- evaluate which measurement technique (LDV, PIV) to employ depending on the problem
- evaluate the measurement data according to their quality and plausibility

**Teaching and Learning Methods:**

The module consists of four parts. At the beginning physical fundamentals to apply laser-optical methods will be developed in group work. Therefore the students look independently into the corresponding literature and offer their results to the other participants using an online-wiki. Afterwards the theory of the two experimental methods is discussed in detail in a lecture. Then experiments on selected problems are performed. There the students to apply their so far gained knowledge of PIV and LDV and learn the typical work flow performing experiments. Finally the students compose a lab report on the experiments performed and present their results in group-presentations to everyone of the class. Then their results, the quality and the way of presentation are discussed in class and evaluated.

**Media:**

presentation, black/white board, script, experiments

**Reading List:**

Rapp, Ch., Le Duc, A. and Pfleger, F.: Fluid Mechanics Laboratory, Fachgebiet Hydromechanik, Technische Universität München (2009),  
Raffel, M. and Willert, C. and Kompenhans, J.: Particle Image Velocimetry, Springer, Berlin, Heidelberg, New York (1998),  
Bauckage, K. et al., Ruck, B. (Hrsg.): Lasermethoden in der Strömungsmesstechnik, AT-Fachverlag, Stuttgart (1990),  
Eckelmann, H.: Einführung in die Strömungsmesstechnik, Teubner, Stuttgart (1997)

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Fluid Mechanics Lab (Praktikum, 2 SWS)

Quosdorf D, von Wenczowski S, Brosda J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV410005: Hydraulics Lab | Hydraulik Praktikum

Version of module description: Gültig ab winterterm 2011/12

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>60  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module is examined by a written exam (60 min.) and a non-graded course achievement. Performing and evaluating outdoor experiments in groups the students demonstrate that they are able to apply the measurement techniques and to analyse the results.

The written exam test their knowledge on the single measurement techniques as well as their evaluation procedure. This exam additionally examines that the students are able to evaluate flow situations in a set time frame and pick a applicable measurement technique for the given situation. The only aids allowed during the exam are a handwritten A4-sheet and a non-programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Prerequisite for this module is the successful completion of the module Fluid Mechanics and Groundwasser (BGU41016) respectively Fluid Mechanics and Turbulence (BV410013).

#### Content:

Theory and practice of flow measurements in natural and man-made channels:

- measurement of depth (ultra sonic, pressure, point gauge)
- hydraulic measurement techniques (venturi channel, measurement wears, flow rate determination using to flow depths)
- salt dilution gauging
- velocimetric techniques (hydrometric impeller, magnetic-inductive current meter, acoustic doppler velocimeter)

#### Intended Learning Outcomes:

After successful completion of this module students are able to:

- explain the different ways to measure flow depth and current
- perform experiments in a team
- measure current in natural and man-made channels using the learned methods
- analyse the results of the flow measurements
- evaluate the applicability of a measurement method to a given flow situation

**Teaching and Learning Methods:**

This lab course consists of three parts: the presentation of the measurement techniques in short talks, the application of the techniques in outdoor experiments and the evaluation of the results. To foster the students capacity for teamwork the students will form small “research teams”. Within these teams they develop short talks on two measurement techniques and are then experts of this techniques for the rest of the semester. The outdoor experiments are then performed and evaluated by bigger groups of about 4-6 students. At the end of the semester each group turns in a protocol and a report of the experiments. By this the students learn the workflow of an experimenter, research of fundamentals, work as a research team, performing and recording of experiments as well as their evaluation.

**Media:**

slides, black/white board, script, outdoor experiments

**Reading List:**

Bollrich, G.: Technische Hydromechanik, Bd. 1, Huss Medien, Berlin (2007)  
Norm DIN V 19218: Durchflussmessung in Fluiden - Verfahren zur Unsicherheitsermittlung (2008)  
Norm ENV 13005: Leitfaden zur Angabe von Unsicherheiten beim Messen (1999)  
Landesanstalt für Umweltschutz Baden-Württemberg (Hrsg.) Durchflussmessung mit der Salzverdünnungsmethode (2002)  
Maniak, U.: Hydrologie und Wasserwirtschaft, eine Einführung für Ingenieure, Springer-Verlag, Berlin (1993)

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydraulik Praktikum (Praktikum, 2 SWS)

Quosdorf D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV410009: Numerical River Hydraulics | Numerische Gerinnehydraulik [NRH]

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination will be written and lasts 60 minutes, all aids will be allowed. Employing questions and small calculation problems the application of theoretical and practical fundamentals will be tested. Additionally the students show, that they are able to characterize the different numerical methods for solving shallow water equations and to evaluate the calculation results according to plausibility.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Prerequisite of this module is the module Applied Hydromechanics (BGU41018T2) and the module Fluid Mechanics and Ground Water Hydraulics (BGU41016) respectively Fluid Mechanics and Transport Mechanisms (BGU41020).

#### Content:

- basic equations of hydromechanics (Navier-Stokes-equation): derivation conservation of mass and momentum, approach to a numerical solution, boundary conditions
- shallow-water equations (2D-St.Venant differential equations): derivation, characteristics, scope of application, boundary conditions
- basics of numerical solvers: discretization of differential equations, numerical grids, numerical approximation, properties of numerical methods
- application of theory using different flow solvers in OpenFOAM for a couple of examples

#### Intended Learning Outcomes:

On successful completion of this module the students are able to:

- apply the basics of theory and code of a 2D-shallow-water program

- model real flow situations in the software
- characterize numerical methods to solve the shallow water equations
- perform simulations using a program which was developed during class
- control the results of the performed simulations using estimations
- evaluate the results of the performed numerical simulations

**Teaching and Learning Methods:**

The module Numerical River Hydraulics consists of two courses:

A classical lecture developing the theory on the black board and a computer lab applying the theory. In the computer lab the basics learned in the lecture will be applied and deepened using the open source software OpenFOAM.

During the semester exercise problems will be provided, which will be solved in groups. These problems encourage the connection of the theory taught in the lecture and the practical application in the lab. The students will work on these exercises at home as well as during the computer lab.

**Media:**

script , black / white board, notes, codes on the computer, computer work

**Reading List:**

- C.J. Beffa, Praktische Lösung der tiefengemittelten Flachwassergleichungen, PhD thesis, ETH Zürich, 1994
- J.H. Ferziger und M. Peric, Computational Methods for Fluid Dynamics, Springer, Berlin, 2002
- P.G. Franke, Hydraulik für Bauingenieure, Walter de Gruyter, Berlin, 1974
- P. Moin, Fundamentals of Engineering Numerical Analysis, Cambridge University Press, Cambridge, 2001

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Michael Manhart (michael.manhart@tum.de)

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Field of Study 6: Resource Efficiency in Urban Planning | Vertiefung 6: Resource Efficiency in Urban Planning

### Required Modules | Pflichtmodule

#### Module Description

### BGU36010: Energy-Building-City | Energie-Gebäude-Stadt

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Duration of examination: 90 min.

The aim of the written examination is to prove that complex building physics of energy, building and city related effects have been understood, can be condensed and applied, in particular dynamic heat transport and energy balances. In order to do this, problems must be detected and solved in a limited time and only with the help of a simple pocket calculator and given formulas. The examination questions cover the entire lecture material. The answers require partly own formulations, partly multiple-choice answers, and in addition to that calculations. No media are allowed except for a simple calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamental knowledge in building physics (heat, moisture, light, acoustics)  
engineering mathematics

#### Content:

The module deals with the fundamentals of dynamic thermal processes, in particular the dynamic one-, two- and three-dimensional heat transfer. These methods are applied to buildings and cities. Related energy balances will be explained. Specific phenomena ranging from small buildings to entire cities are depicted.

**Intended Learning Outcomes:**

Upon completion of the module, students will be able to quantitatively determine and evaluate complex building physics phenomena in the field of Energy-Building-City, as well as to characterize the related interrelations.

In addition, they are also able to independently develop adequate solutions for the typical building physics tasks in the areas of heat, humidity and energy. They can also abstract the building physics phenomena to other climatic regions.

After participating in the module, the students will understand more detailed principles of building physics methods of thermodynamics. They can analyze the associated processes at building level and at city level and can develop concepts and technology applications to influence them in the long term.

**Teaching and Learning Methods:**

The module consists of lectures and exercises. The competencies in the areas of energy of components, buildings and cities are taught in the form of lectures through presentations. In the associated exercises, the topics taught (energy aspects of components, buildings and cities) are deepened by means of short repetitions and calculation exercises on theoretical problems and on application problems. In the context of the exercises for all parts, text tasks supplemented with sketches and diagrams are precalculated, which are also summarized in task sheets.

**Media:**

Powerpoint presentations, blackboard work, films

**Reading List:**

Gösele, Schüle, Künzel: Schall, Wärme, Feuchte. Bauverlag Wiesbaden, 10. völlig neu bearbeitete Auflage (1997).

Lutz, Jenisch, Klopfer, Freymuth, Krampf: Lehrbuch der Bauphysik - Schall, Wärme, Feuchte, Licht, Brand - B.G. Teubner, Stuttgart (1997).

Richter, Fischer, Jenisch, Freymuth, Stohrer, Häupl, Homann: Lehrbuch der Bauphysik - Schall - Wärme - Feuchte - Licht - Brand - Klima - Vieweg+Teubner, Wiesbaden (2008).

Bauphysik-Kalender 2001. Hrsg. E. Cziesielski. Ernst & Sohn Verlag Berlin (2001).

Sälzer, E.: Schallschutz im Massivbau. Bauverlag Wiesbaden (1990).

Zürcher, Ch.: Bauphysik. Verlag der Fachvereine Zürich, (1988).

Hauser, G., Stiegel, H.: Wärmebrücken-Atlas für den Mauerwerksbau. Bauverlag Wiesbaden, 3. durchgesehene Auflage (1996).

**Responsible for Module:**

Prof. Klaus Sedlbauer

**Courses (Type of course, Weekly hours per semester), Instructor:**

Energie - Gebäude - Stadt (Vorlesung, 4 SWS)

Göttig R

Bauphysik Vertiefung 2 Gebäude/Stadtteil- Übung (Übung, 1 SWS)

Göttig R [L], Gocht S

Bauphysik Vertiefung 2 Gebäude/Stadtteil- Vorlesung (Vorlesung, 3 SWS)

Sedlbauer K [L], Sedlbauer K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU62064: Sustainable Architecture, Urban and Landscape Planning - for Environmental Engineering | Nachhaltige Architektur, Stadt- und Landschaftsplanung - für Umweltingenieurwesen [SAULP-for ee]**

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Type of examination: scientific paper

The form of examination is a scientific paper consisting of two parts. Part A is individual work (30%) and part B (70%) is group work. The total volume is about 12-14 pages per person and should be uploaded via Moodle.

#### **Part A**

Analytical summary of the contents of the various lectures against the background of the sustainable city, taking into account the ecological, socio-cultural and economic aspects in relation to the challenge of building with a positive ecological footprint.

Students should be able to reflect the general sustainability criteria (such as settlement density, settlement structure) in their entirety and be able to explain urban planning aspects (such as separation of functions and mixing of functions with regard to the quality and quantity of traffic movements) and the use of greenery in the city.

#### **Part B**

Working on a topic of specialisation in which the essential approaches of sustainable architecture urban and landscape planning in the fields of materials, building concepts, energy supply and integration of renewable energies as well as in urban development, spatial planning and in accessibility and mobility are presented, analysed, interpreted and applied in summary form. The topics will be assigned at the beginning of the semester.

#### **Repeat Examination:**

Next semester



**(Recommended) Prerequisites:**

Successful participation in module

Sustainable Building Basic Module BGU62056

**Content:**

The module consists of a lecture series and a seminar that focuses on the contents of the lectures. The module presents the main approaches to sustainable architecture, urban and landscape planning and analyses and evaluates the interfaces and interactions between the subject areas within the overall system.

In the course of the lecture, technical experts convey the basics of planning in the areas of landscape architecture/public space, interactions between spatial and transport planning, sustainable urban development, accessibility as a basis for designing sustainable mobility, electromobility, regenerative energy systems/energy management, building physics/energy-efficient construction, energy use, resource-saving construction, building materials and materials, construction technology and life cycle engineering, comfort and load management, real estate development and valuation, and digital tools for early design planning.

In the seminar, the individual topics are taken up and examined in depth. Connections between urban planning, architectural and technical concepts are taught and the associated energy, material and traffic flows are shown. Starting from the cultural-historical classification and the historical development of sustainability, approaches to solutions for the consideration of engineering aspects with regard to sustainable planning and action are examined and developed. This is done by means of examples on a topic-related basis, in part also independently. An overview of the systemic interaction of the individual planning components is developed, on the basis of which the effects of decisions of the individual planning participants on the overall planning system are clarified

**Intended Learning Outcomes:**

After attending the module, students are able to

- to understand general sustainability criteria in architecture, urban and landscape planning in existing and new buildings and groups of buildings and the associated systems in the fields of materials, building concepts, energy supply and integration of renewable energies as well as in urban development, spatial planning and in accessibility and mobility
- to understand the interrelationships of the consumption of resources (energy, material, water)
- to analyse questions of energy and resource use in the building sector with regard to the potential of sustainable planning
- to evaluate the interrelationships and the systemic interaction of the individual planning components to achieve sustainable planning approaches
- to independently analyse current political and regulatory frameworks and the issues they contain on the basis of the characterised systemic effects
- evaluate the effects of planning decisions on the overall system
- to independently and critically examine current issues and to develop appropriate strategies and solutions.
- to reflect learned complexes of topics in a condensed form and to give presentations

### **Teaching and Learning Methods:**

The teaching content of the lecture is conveyed through lectures by subject experts. In order to deepen the content of the lectures, the students provide a short written summary of the essential statements of the experts and place the lecture in the context of the sustainable city. Based on this and on supplementary lectures, discussions are held on issues of sustainable planning in the various fields in order to analyse the teaching material and develop possible solutions. Furthermore, supplementary contents and calculation methods will be developed and presented in group work. In group work, the teaching content can be discussed already during the summary, so that a deeper examination of the topic is achieved. The presentation in front of the entire seminar group enhances the students' skills of condensed reproduction as well as their presentation skills.

### **Media:**

Presentations, Videos, Literature

### **Reading List:**

McDonough, W., & Braungart, M. (2002). Cradle to cradle: Remaking the way we make things (First edition). New York: North Point Press.

Heck, H.-D., & Meadows, D. L. (1972). Dennis Meadows [u.a.] Die Grenzen des Wachstums (The limits to growth, dt.).

Friedman, T. L. (2009). Hot, flat, and crowded: Why we need a green revolution--and how it can renew America (Release 2.0, updated and expanded ; 1st Picador ed.). New York: Picador/Farrar, Straus and Giroux.

### **Responsible for Module:**

Prof. Dr.-Ing. Werner Lang

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Nachhaltige Gebäudeplanung im urbanen Kontext (Seminar, 2 SWS)  
Lang W [L], Hernández Chamorro A, Lang W, Schwering K

Nachhaltige Architektur, Stadt- und Landschaftsplanung - Vorlesung (Vorlesung, 2 SWS)  
Lang W [L], Hernández Chamorro A, Lang W, Schwering K, Staudt J  
For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Elective Modules | Wahlmodule

### Module Description

#### BGU62043: Aspects of Sustainable Urbanism | Aspects of Sustainable Urbanism

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

written/drawn, cumulative exercises: The Module consists of two parts (A+B) and will be credited with 6 ECTS when both parts are passed successfully.

Part A (40%, individual work): Lecture series and accompanying workshop. Completion of one assignment, that will be developed (from various disciplinary perspectives of sustainable urban design) during workshop sessions and presented in the final session. The assignment will require students to investigate and discuss the presented topics within the particular context of a city.

Attendance at the lecture and workshop sessions is mandatory.

Part B (60%, group work): Individual reflection of lecture content, workshop results and reading in a short text and graphic summary as a poster and presentation.

Part A and B are Uploads on Moodle.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

No previous knowledge in the field is required.

#### Content:

The module provides systemic insight into basic principles of Urban Planning and Design, Urban (Re-)Development, based on key principles Sustainable Urbanism. Focal aspects are (amongst others): – the perception and exploration of key challenges of transformation, techniques of problem identification and conceptualization of resolution strategies in the urban realm, – application of exemplary morphologic and physiologic indicators of urban structure, as well as – the illustration of urban regenerations processes in best practise urban projects. The module

confronts the student with a repertoire of possibilities to integrate complex spatial, aesthetic, social, cultural, ecological and sustainable qualities into contemporary living environments. Physical encounters with the city (on-site workshops) are featured for studying important urban settings and city phenomena in real life.

**Intended Learning Outcomes:**

After attending the lecture and completing the exercises, the students are able to recognize and understand current patterns of transformation of contemporary urban and suburban structures including connections between ecological, societal and economic factors. Based on the presentation of examples, students can reflect and understand basic ideas and approaches towards more sustainable living environments. Workshop sessions provide insight into the application of basic instruments of urban design and sustainable urban development and enable students to make connections with the focus of their major field of study and its toolsets.

**Teaching and Learning Methods:**

Lecture series that feeds into a practice seminar: Basic urban design topics are introduced by lecture to then be individually applied in the workshop researching actual plots.

**Media:**

keynote, exercise sheets, sketching paper

**Reading List:**

Jane Jacobs. The death and life of great American cities. 1961.

Jan Gehl. Cities for people. 2010.

David Graeme Shayne. Recombinant Urbanism. 2005.

**Responsible for Module:**

Werner Lang sekretariat.enpb.bgu@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Sociocultural Perspectives of Sustainable Cities (Aspects of Sustainable Urbanism) (Vorlesung, 2 SWS)

Lang W [L], Schade C, Schwering K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU62051: Sufficiency in Architecture and Engineering | Suffizienz im Bauwesen

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The performance record consists of a scientific paper with a final presentation of the results, whereby the presentation is included in the overall grade with 20%.

With the scientific elaboration and the associated presentation, the students demonstrate that they have understood and can apply the different aspects of sufficiency. In addition, the students should be able to develop strategies and approaches to solutions on the topic of sufficiency in the building industry by themselves.

The scientific paper has to be uploaded on Moodle.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

What does sufficiency mean? Sufficiency as a life goal? What role does sufficiency play in architecture and engineering? These and other questions are centered around one of the core areas of the sustainability concept – not only with regard to architecture and engineering. The seminar therefore explores the significance of the “sufficiency” concept to our quality of life and the consumption of resources this involves. Foundations and various aspects of sufficiency and of the sustainability concept in architecture and engineering are discussed and considered in the context of current developments and plans by experts from various disciplines (natural sciences, engineering and the humanities). Apart from fundamental aspects, recent findings from research and practice in the field of sufficiency are presented and explored in more detail in the paper drafted by the participants.

Structure / content:

Part 1: The lectures given by experts from various fields of specialization during the seminar will present and discuss the following topics in the light of the concept of sufficiency:

- Philosophy
- Economics
- Sociology
- Technology
- Engineering
- Architecture / landscape architecture
- ..

The contents and topics are conveyed in the form of a lecture, based on vivid presentations using charts, pictures and short films. In addition, interesting articles and recommended literature are made available for download on the website.

Part 2: In the second part of the seminar, selected topics are studied in greater depth by the students while special topics are explored by participating in related events or excursions

### **Intended Learning Outcomes:**

Students who have completed the module have gained an understanding of the elements of the sufficiency concept and are able to apply them to their future professional activity in designing, planning and implementing urban districts and buildings.

### **Teaching and Learning Methods:**

The module consists of a seminar. The seminar firstly consists of lectures presented by experts with various specializations from research and practice. The lectures are intended to create an awareness of the topic among students, to encourage them to thoroughly study it and to give them insights into the topic of sufficiency from various perspectives. Secondly, the seminar consists of activating teaching methods, which include presentations given by the students, discussions, research and group work. Therefore, the independent development of strategies and solutions is encouraged.

In addition, excursions and visits to relevant events are offered. This approach enables an enhanced transfer of knowledge beyond the ambit of the TUM.

### **Media:**

PowerPoint, script, films, worksheets

### **Reading List:**

Fuhrhop, Daniel (2015): Verbiestet das Bauen! Eine Streitschrift. 2. Auflage. München: oekom Verl. oekom e. V. (Hg.) (2013): Politische Ökologie. Suffizienz als Schlüssel zu mehr Lebensglück und Umweltschutz. Oekom e.V. München: Oekom-Verl. (Politische Ökologie, 135).  
Stengel, Oliver (2010): Suffizienz. Dissertation. Wuppertal Institut für Klima, Umwelt, Energie.  
Welzer, Harald (2013): Selbst denken. Eine Anleitung zum Widerstand. 5. Aufl. Frankfurt am Main: Fischer.

### **Responsible for Module:**

Werner Lang sekretariat.enpb.bgu@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Suffizienz im Bauwesen (Seminar, 4 SWS)

Lang W [L], Hernández Chamorro A, Lang W, Schwering K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU62059: Application of an Life Cycle Assessment for Civil Engineering | Anwendung einer Lebenszyklusanalyse für Bauingenieurwesen

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a scientific paper including a short presentation.

In the wiss. (30-40 pages) the students show whether they are able to reproduce a concrete application of a life cycle analysis (LCA) on an existing or planned building in a scientifically correct way. The aim of the paper is to examine to what extent a know. The elaboration aims at checking to what extent a scientific analysis of the task is carried out under the aspects of the application of target-oriented scientific methods. The concrete application of a life cycle analysis (LCA) to a building is based on an example project.

In a short presentation (approx. 10 min.) the students show that they are able to rhetorically reproduce the facts and that they are able to engage in a dialogue with the audience on the topic. The examination performance takes place online: the scientific paper is uploaded via Moodle and the presentations take place via ZOOM.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The successful participation in the module LCA BV360009

#### Content:

The content of the module Application of a Life Cycle Analysis (LCA) consists of

- Teaching the basics of a building LCA
- Mediation of software knowledge for the implementation of a LCA
- Calculation and evaluation of energy and CO<sub>2</sub> balances at material and component level
- Identification of potentials for reducing environmental impacts



- Students work independently on a given project
- Presentation of the elaborated results in a lecture and elaboration of a seminar paper

### **Intended Learning Outcomes:**

After participating in the module, the students are able to

- reflect a sound basic understanding of life cycle assessment
- to adequately evaluate the results of the life cycle assessment.
- to analyse energy and CO<sub>2</sub> balances.
- To understand the most important ecological parameters of a building.
- to apply calculations in a life cycle assessment software (eLCA) to specific buildings.
- to analyse existing building structures with regard to the components and materials used over all life cycle phases and to develop optimisation proposals
- Develop recommendations for ecological optimisation of a building design, taking into account all life cycle phases.
- to reflect a life cycle analysis on a building in a scientifically correct way.

### **Teaching and Learning Methods:**

The module consists of one seminar. In the seminar there are individual input lectures to give the students the necessary basics about life cycle assessment and life cycle analysis. Based on the lectures, the application of this knowledge takes place in the seminar using a concrete example project. The students work on the tasks in groups and are supervised by the teacher (group work, seminar). The participants develop sustainable building components and identify the associated effects on the building and the environment, focusing on the application of a life-cycle approach to the concrete building and understanding the most important adjustment screws. It is particularly important to develop and answer ecological questions in early planning phases on a project-specific basis.

### **Media:**

Power Point, eLCA

### **Reading List:**

DIN, ENISO. 14044: 2006-10 Umweltmanagement–Ökobilanz–Anforderungen und Anleitungen. DIN Deutsches Institut für Normung eV Berlin: Beuth Verlag, 2006. DIN, ENISO. 14040: Umweltmanagement–Ökobilanz–Prinzipien und allgemeine Anforderungen. Deutsche Fassung der EN ISO, 1997, 14040. Jg., Nr. 1997, S. 16. KÖNIG, Holger, et al. Lebenszyklusanalyse in der Gebäudeplanung. Institut für internationale Architektur-Dokumentation, München, 2009.

### **Responsible for Module:**

Prof. Dr.-Ing. Werner Lang sekretariat.enpb.bgu@tum.de

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Anwendung einer Lebenszyklusanalyse (Seminar, 4 SWS)

Lang W [L], Schwering K, Takser I, Theilig K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU62062: TUM.city | TUM.stadt

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module's examination consists of an exam (90 minutes) and a voluntary mid-term performance in the form of a scientific work. With the written exam, students demonstrate that they are able to reflect the theoretical knowledge on City & Water, understand the interdisciplinary interactions and are able to evaluate them in practice.

The scientific work consists of a written paper (approx. 12 pages) and a final presentation. The students work on a chosen topic in the area of City and Water in greater depth. Here, the students show that the interdisciplinary aspects of a healthy city have been understood and how these can be analysed, interpreted and applied. With the oral presentation of the scientific paper the contents and results are presented.

The grade of the scientific paper can be credited with 33% of the overall grade if the exam is passed to improve the grade.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Participation in the lecture TUM.stadt.

#### Content:

The course is based on the contents of the lecture.

What ecological, economic and social challenges do cities face with regard to climate change and redensification?

How can interdisciplinary approaches to solutions be developed?

What are the interfaces/encounters from the different disciplines on the topic of "City & Water"?

These and other questions are aimed at the core areas of a liveable city and this requires the interdisciplinary collaboration of planners, engineers, natural scientists, social scientists, economists and life scientists.

The following contents will be dealt with in the lecture and seminar:

- Identification of the networking of engineers, architects, natural scientists, social scientists, economists and life scientists.
- Exploration of new, interdisciplinary basic knowledge
- Exploration of interfaces/synergies and contradictions on the topic of the city through different disciplines.
- Identification, analysis and, if necessary, further development of relevant urban systems
- Impulses for the transformation of our living environments
- Development of new research questions
- Development of new interdisciplinary approaches to solutions
- Practice of working together across disciplines

The contents and topics are taught in the form of lectures, which are deepened in the seminar through interdisciplinary collaboration practice and guidance of the experts.

Graphics, pictures, short films or other suitable forms are used to illustrate the topics. In addition, interesting articles and literature recommendations are made available for download via Moodle.

### **Intended Learning Outcomes:**

After successful participation in the course, students are able to evaluate the subject-related and interdisciplinary interactions (synergies, potentials, contradictions) with regard to city and e.g. well-being, water or mobility.

### **Teaching and Learning Methods:**

The seminar builds on the lecture TUM.stadt. Experts from interdisciplinary fields are involved in the lecture series.

The teaching content of the lecture is conveyed through tandem lectures. These lectures are intended to sensitise students

to the topic of "City & Water", encourage them to discuss the content and give them insights into the subject area from different

specialist perspectives. The subsequent seminar is supervised by the assistants from the previous lecture and the initiators of TUM.stadt.

The students will be sensitised to the topic of "encounter city" through group work, on-site visits, etc., in order to actively and

consciously experience connections such as trees for shading, density, heat, stress,... or water as a design tool, food, medium for

leisure and health or natural hazard. Based on the knowledge gained, the students have to develop solutions in theory.

**Media:**

PowerPoint presentation, live feedback, blackboard work, video

**Reading List:**

Wang, Xiaochang C.; Fu, Guangtao (2021): Water-Wise Cities and Sustainable Water Systems: Concepts, Technologies, and Applications: IWA Publishing.

Grant, Gary (2016): The Water Sensitive City. Chichester, UK: John Wiley & Sons, Ltd.

Haass, Heiner (2010): StadtWasser. Wasserkonzepte in der Stadtplanung. Stuttgart: Fraunhofer-IRB-Verl. (StadtGestaltung).

Russell, James S.: The Agile City. Building Well-being and Wealth in an Era of Climate Change. Washington DC, 2011.

Bott, H., Grassl, G.C., & Anders, S. (2014). Nachhaltige Stadtplanung: Konzepte für nachhaltige Quartiere. [München]: Detail.

Ekardt, F. (2016). Theorie der Nachhaltigkeit: Ethische, rechtliche, politische und transformative Zugänge - am Beispiel von Klimawandel, Ressourcenknappheit und Welthandel (2., vollständig überarbeitete und aktualisierte Auflage). Baden-Baden: Nomos.

Friedman, T. L. (2009). Hot, flat, and crowded: Why we need a green revolution--and how it can renew America (Release 2.0, updated and expanded ; 1st Picador ed.). New York: Picador/Farrar, Straus and Giroux.

Meadows, D. H., Meadows, D. L., & Randers, J. (1992). [Hauptband] (6. Aufl.). Die neuen Grenzen des Wachstums: die Lage der Menschheit: Bedrohung und Zukunftschancen / Donella H. Meadows: A. Stuttgart: Dt. Verl.-Anst.

**Responsible for Module:**

Markus Disse markus.disse@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU62063: TUM.city - Lecture Series | TUM.stadt - Vorlesungsreihe

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

By means of comprehension questions in a written exam (90 minutes), it is tested to what extent the students have acquired the theoretical basic knowledge of "City & Water", understand the interdisciplinary interactions and evaluate these in action.

Answering the questions requires the students to formulate their own answers. The content taught in the lecture course is tested under time pressure and without aids.

#### Repeat Examination:

#### (Recommended) Prerequisites:

none

#### Content:

What ecological, economic and social challenges do cities face with regard to climate change and redensification?

How can interdisciplinary approaches to solutions be developed?

What are the interfaces/encounters from the different disciplines on the topic of "City & Water"?

These and other questions are aimed at the core areas of a liveable city and this requires the interdisciplinary networking of planners, engineers, natural scientists, social scientists, economists and life scientists.

The following contents will be dealt with in the course:

- Identification of the networking of engineers, architects, natural scientists, social scientists, economists and life scientists.

- Exploration of new, interdisciplinary basic knowledge
- Exploration of interfaces/synergies and contradictions on the topic of the city through different disciplines. Disciplines
- Identification, analysis and, if necessary, further development of relevant urban systems
- Impulses for the transformation of our living environments
- Development of new research questions
- Development of new, theoretical approaches to solutions

In the course of the lecture, representatives from various disciplines will present and discuss the following topics on the main theme of "City & Water":

- Urban River Restoration
- Urban Green Infrastructure
- Climate Change
- Flood Resilience
- Sponge-City
- Real Estate
- Urban Agriculture
- Urban Water Management
- Water Rights– Water Governance
- Water Quality in Megacities
- Blue-Green Cities in Germany

Within the specific topics, the following general topics are also addressed:

- City
- Landscape
- Sociology
- Regional Planning
- Health
- Water/Wastewater
- Pollutants
- Energy
- Economics
- Law
- Climate Change
- Natural Hazards
- Ecology

The contents and topics are taught in the form of lectures. Graphics, pictures and short films are used to illustrate the topics.

In addition, interesting articles and literature recommendations are made available for download via Moodle.

**Intended Learning Outcomes:**

After successful participation in the module, the students are able to evaluate the subject-related and interdisciplinary interactions (synergies, potentials, contradictions) with regard to focal topic "City & Water".

**Teaching and Learning Methods:**

The module consists of a lecture series.

Experts from interdisciplinary subject areas are involved in the lecture series. The teaching content of the lecture is conveyed through tandem lectures. These lectures are intended to sensitise students to the main topic "City & Water", to encourage them to discuss the content and to give them insights into the subject area from different specialist perspectives.

**Media:**

PowerPoint presentation, live feedback, blackboard work, video or appropriate on-line media.

**Reading List:**

Wang, Xiaochang C.; Fu, Guangtao (2021): Water-Wise Cities and Sustainable Water Systems: Concepts, Technologies, and Applications: IWA Publishing.

Grant, Gary (2016): The Water Sensitive City. Chichester, UK: John Wiley & Sons, Ltd.

Haass, Heiner (2010): StadtWasser. Wasserkonzepte in der Stadtplanung. Stuttgart: Fraunhofer-IRB-Verl. (StadtGestaltung).

Russell, James S.: The Agile City. Building Well-being and Wealth in an Era of Climate Change. Washington DC, 2011.

Bott, H., Grassl, G.C., & Anders, S. (2014). Nachhaltige Stadtplanung: Konzepte für nachhaltige Quartiere. [München]: Detail.

Ekaradt, F. (2016). Theorie der Nachhaltigkeit: Ethische, rechtliche, politische und transformative Zugänge - am Beispiel von Klimawandel, Ressourcenknappheit und Welthandel (2., vollständig überarbeitete und aktualisierte Auflage). Baden-Baden: Nomos.

Friedman, T. L. (2009). Hot, flat, and crowded: Why we need a green revolution--and how it can renew America (Release 2.0, updated and expanded ; 1st Picador ed.). New York: Picador/Farrar, Straus and Giroux.

Meadows, D. H., Meadows, D. L., & Randers, J. (1992). [Hauptband] (6. Aufl.). Die neuen Grenzen des Wachstums: die Lage der Menschheit: Bedrohung und Zukunftschancen / Donella H. Meadows: A. Stuttgart: Dt. Verl.-Anst.

**Responsible for Module:**

Markus Disse markus.disse@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV360009: Life-cycle Assessment | Ökobilanzierung

Version of module description: Gültig ab winterterm 2017/18

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The course's performance assessment will be one written exams. The written exam will test the students' ability to reproduce precisely the essential elements of life cycle assessment in general and in the context of building constructions as well as transfer this knowledge to different setting in a limited amount of time. The integration of case studies tests their knowledge, understanding and the ability of identification and adaptation of basic principles under time pressure. The exam consists of case studies, knowledge and comprehension questions and problems as well as of multiple-choice questions, calculations and open questions.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Grundlagen der Nachhaltigkeit

#### Content:

The module 'Lifecycle Assessment' takes place during winter semester. The essential content of the course is the Life Cycle Assessment Method and cross-linked thinking regarding environmental aspects, interdependencies and the interpretation of these.

The course 'Lifecycle Assessment' gives an overview over the context of Life Cycle Assessment and different, alternative assessment methods. Therefore, the course illustrates general aspects and processes of a LCA as well as specific characteristic of LCA in the building sector. This distinction enables the students to draw nuanced conclusions to decisions and approaches of action. The international and national regulation form the basis of this seminary. The elemental knowledge to compile a LCA consists of:

- Goal and scope definition
- Lifecycle inventory analysis (LCI) and product systems



- Lifecycle impact assessment (LCIA), indicators and endpoint categories
- Interpretation, iteration and analysis
- Environmental product declaration and databases
- Allocation
- Substitution and End-of-Life aspects
- Recycling, use phase and lifetime of building components

A workshop with focus on the application of this method, parallel to the lectures enables a deeper understanding and practical application of the theoretic elements of the lecture. The realistic context with a building as an example offers a direct approach to deal with datasets, databases and to gradually build implement and build up a lifecycle calculation within MS Excel. Lectures from partners with practical experience offer an outlook to the wide range of possibilities for application and integration of LCA.

### **Intended Learning Outcomes:**

After participating in the module 'Life-Cycle-Assessment', students will be able to understand and apply the method of lifecycle assessment as well as to make use of the principal of cross-linked thinking regarding environmental aspects, interdependencies and the interpretation of these. This includes the basics of an environmental assessment, as well as the understanding and application of the functional principles considering the content, processes and methods of LCA. The can describe and understand the regulation background of LCA on an international and national basis. The participants will be able to design a goal and scope definition for the LCA of products and buildings and to develop and perform the calculation. The students can master the application and interpretation of datasets and databases (like ökobau.dat, ecoinvent etc.) quantitatively and understand the principle of operation of different LCA-tools (like eLCA, LEGEP, GaBi etc.). The will also be able to interpret the results appropriately.

### **Teaching and Learning Methods:**

The module consists of lectures and practice sessions with blackboard and presentations. Additional practice sessions supplement the lectures by the application and calculation in MS Excel. The students can process case studies and systematic tasks for individual learning.

### **Media:**

Presentations, blackboard presentations, script (lecture-slides) transcript

### **Reading List:**

Script and literature from the mandatory pre-requisite modules, personal transcript will be necessary

- Informationsportal Nachhaltiges Bauen: [www.nachhaltigesbauen.de](http://www.nachhaltigesbauen.de)
- IPCC Reports
- Water Footprint Assessment Manual (2011)
- Ecological Footprint Atlas (2010)
- ILCD Handbook - General guide for LCA (2010)
- Humbert et al. (2012) - Impact 2002+ User Guide

- Rüter et al (2012) - Ökobilanz-Basisdaten für Bauprodukte aus Holz
- Klöpffer, W. (2014) - Ökobilanz (LCA)
- Kohler, König et al. (2010) - A life cycle approach to buildings
- Khouli, John et al (2015) - Sustainable Construction Techniques
- Guinée et al (2001), LCA - An operational guide to the ISO-standards
- Eyerer, P.: Ganzheitliche Bilanzierung, Werkzeug zum Planen und Wirtschaften in Kreisläufen; Springer Verlag; Heidelberg, Berlin, New York (1996).
- DIN EN ISO 14040:200911 Umweltmanagement Ökobilanz Grundsätze und Rahmenbedingungen
- DIN EN ISO 14044:200610 Umweltmanagement Ökobilanz Anforderungen und Anleitungen
- DIN EN 15804:2014-07: Nachhaltigkeit von Bauwerken - Umweltproduktdeklarationen - Grundregeln für die Produktkategorie Bauprodukte
- DIN EN 15978:2012-10: Nachhaltigkeit von Bauwerken - Bewertung der umweltbezogenen Qualität von Gebäuden - Berechnungsmethode

**Responsible for Module:**

Stefan Winter (bauko@bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Ökobilanzierung (Vorlesung mit integrierten Übungen, 2 SWS)

Winter S [L], Hartmann M, Ott S, Wagner A, Ebert S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV620003: Interaction between Sustainability and Building Culture | Wechselwirkungen zwischen Nachhaltigkeit und Baukultur**

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The examination is the supervised preparation of a scientific paper (approx. 20 pages) in teams of 2-3 students, which has to be uploaded on Moodle.

By analysing sample projects within their chosen topic, the students demonstrate that they are fully familiar with the criteria of sustainability and building culture. The subsequent examination of the interactions, such as synergies and conflicts between sustainability and building culture, shows the ability of an in-depth, structured examination of their diverse and sometimes conflicting requirements.

The students demonstrate their competence in assessing the implementation of building culture aspects and sustainability requirements by means of a differentiated argumentative presentation.

At the end of the semester, the scientific elaboration will be presented in a presentation (20 min.) to test the communicative competence of the presentation of scientific studies and the resulting lines of argumentation.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Participants should have gained initial experience in designing or executing construction projects as part of their studies. Students should be familiar with the contents of the lecture "Fundamentals of Sustainable Building".

#### **Content:**

Contents:

- History of sustainability in construction

- Assessment criteria for sustainability
- What is building culture? Evaluation criteria of building culture and architectural-spatial quality
- Mutual influence of sustainability and building culture
- Sustainability in the building industry of other cultures (e.g. influence of climate or local factors on building forms)
- Analysis of the current situation in Europe (e.g. competition results with the topic sustainability, built example projects)
- Motives for using sustainability as a design criterion (e.g. the PR effectiveness of "green")
- "Nimby" - not in my backyard: Sustainability in practice
- Bringing strategies, sustainability and building culture into harmony

### **Intended Learning Outcomes:**

After attending the module, students are able to

- to discuss the importance of sustainability as a design criterion
- to recognise the responsibility of the planning disciplines for the quality of the buildings and to describe the possibilities of planning influence in the context of integral planning
- to understand the development of the identity of traditional and vernacular building cultures from technical and climatic requirements of a country or region
- explain criteria for the assessment of building culture and apply them to examples of projects
- to implement sustainability aspects in the design process, taking into account the impact on building culture
- to investigate conflicts of objectives and synergies between building culture and sustainability
- to analyse the connection between the requirements of sustainability and their effects on building culture in building and civil engineering projects and to assess the project from these aspects

### **Teaching and Learning Methods:**

The module consists of a lecture and a seminar.

The lecture creates the content basics by imparting theoretical knowledge and giving insights into current developments. Specialist experts complement the lecture as guest speakers to illustrate the practical relevance and application. By representing different perspectives on the requirements of sustainability and building culture, the lectures encourage students to reflect on the topic in subsequent discussions.

Excursions are used to deepen and illustrate the contents of the lectures.

In the seminar, the topics are dealt with in greater depth and a detailed examination of individual questions is allowed. Aspects of the topic will be developed in workshops and discussions at the beginning.

In teams of 2-3 students the critical examination of the interactions between building culture and sustainability (e.g. conflicts of objectives and synergies) will be deepened in the course of the semester. For this purpose, topics are selected (e.g. specific building typologies or projects). On the basis of these, students apply the acquired specialist knowledge by examining and assessing projects in the selected topic area with regard to the interactions.

The result is prepared in the form of a written, scientific paper and presented in a seminar presentation.

**Media:**

Powerpoint, moderation cards (workshop work), blog

**Reading List:**

- Durth, W., Sigel, P., Baukultur - Spiegel gesellschaftlichen Wandels, Jovis Verlag, Berlin, 2009
- Weeber, H., Weeber, R., Baukultur! Bundesministerium für Verkehr, Bau und Stadtentwicklung, Berlin, 2007
- Bundesstiftung Baukultur, Nagel, R. (Hrsg.), Baukulturbericht 2014/15, Gebaute Lebensräume der Zukunft – Fokus Stadt Potsdam, 2014

**Responsible for Module:**

Prof. Werner Lang sekretariat.enpb.bgu@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Wechselwirkungen zwischen Nachhaltigkeit und Baukultur - Vorlesung (Vorlesung, 2 SWS)  
Lang W [L], Koth S, Schwering K

Wechselwirkungen zwischen Nachhaltigkeit und Baukultur - Seminar (Seminar, 2 SWS)

Lang W [L], Koth S, Schwering K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV620006: Special Topics in Sustainable Design | Sonderthemen des nachhaltigen Bauens

Version of module description: Gültig ab winterterm 2018/19

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Lecture with preparation and follow-up of the lecture contents. Independent development of strategies and approaches to solutions, which are presented at the end of the semester in the form of a scientific paper and a presentation. The examination in the form of a presentation and a scientific paper is intended to demonstrate that students are able to deal with current research topics over a period of one semester and to critically examine them. In the process, various questions from the fields of building physics, architecture and technical building equipment are addressed and applied and evaluated in a research-related manner.

In interaction with the examiners, typical problems are to be analysed in a result-oriented way and the possible solutions are to be brought into a meaningful context.

The form of the oral assessment allows for iterative questions of increasing complexity and the individual approach to the students, which enables a realistic assessment of the competences acquired in the module.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Grundkenntnisse in der Architektur/Bauphysik/Gebäudetechnik

#### Content:

As drivers of science and research, universities are continually expanding their ties with the business world. The ring lectures, which take place at regular intervals, give students insight into practical work experience. The lecturers will both share experience from their companies and be available for discussions on topics from the public sector and other fields of research. In collaboration with the Oskar von Miller Forum.

**Intended Learning Outcomes:**

Connect students to current issues from the real world. Provide insight into topical discussions from a group of themes and establish contact with companies.

**Teaching and Learning Methods:**

The course takes the form of a classic lecture, followed by discussions between the students and experts from research and business. Students participating in the lecture select one topic/object each from the following teaching content at the beginning of the semester, which is to be researched intensively throughout the semester. At the end of the semester, the result is outlined in a short presentation.

**Media:**

lecture notes, data projector presentation

**Reading List:**

Hegger, Manfred ; Fuchs, Matthias ; Stark, Thomas ; Zeumer, Martin: Energie Atlas : Nachhaltige Architektur. Berlin: Walter de Gruyter, 2007.

Kaltschmitt, Martin ; Streicher, Wolfgang ; Wiese, Andreas: Erneuerbare Energien : Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Berlin Heidelberg New York: Springer-Verlag, 2013.

Lenz, Bernhard ; Schreiber, Jürgen ; Stark, Thomas: Nachhaltige Gebäudetechnik : Grundlagen - Systeme - Konzepte. Berlin: Walter de Gruyter, 2010.

**Responsible for Module:**

Prof. Werner Lang sekretariat.enpb.bgu@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### ED120049: Interdisciplinary Summerschool Urban Design | Interdisziplinäre Summerschool Städtebau

Version of module description: Gültig ab summerterm 2022

|                                         |                                    |                                  |                                      |
|-----------------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5                   | <b>Total Hours:</b><br>150         | <b>Self-study Hours:</b><br>75   | <b>Contact Hours:</b><br>75          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung ist eine Projektarbeit, die Bewertung erfolgt anhand dem im Kurs erarbeiteten Konzept für einen transformativen Eingriff im urbanen Raum. Mit dem Konzept wird die Fähigkeit nachgewiesen, städtebauliche Fragestellungen konzeptionell und in einem interdisziplinären Team bearbeiten zu können. Die Beurteilung erfolgt anhand der abgegebenen Dokumentation und der Präsentation. Anhand dieser wird geprüft, ob die Studentinnen und Studenten in der Lage sind, ihre Konzepte verständlich, präzise und anschaulich darzustellen und dabei überzeugend und professionell aufzutreten.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Basisverständnis urbaner Transformationsprozesse
- Grundkenntnisse analoger sowie digitaler Zeichnungsmethoden
- Grundkenntnisse der infrastrukturellen Organisation von Städten

#### Content:

Die Studierenden leiten in interdisziplinären Teams Erkenntnisse aus den Ergebnissen vorangegangener städtebaulicher Aushandlungsprozesse mit Forschungs- und/oder Praxisbezug ab. Diese werden hinsichtlich der Aspekte Nachhaltigkeit, Gerechtigkeit und weiterer Aspekte bewertet, formuliert und dienen als Ausgangslage eines Kurzentwurfs oder mehrerer Kurzentwürfe. In diesem werden räumliche, soziale und infrastrukturelle Merkmale einer spezifischen urbanen Situation analysiert und Konzepte zu deren Umgestaltung generiert, ggf. auch mit Beteiligung von Externen im Sinne eines Co-Design-Prozesses.



### **Intended Learning Outcomes:**

Nach der Teilnahme an den Modulveranstaltungen sind die Studentinnen und Studenten in der Lage

- die Relevanz eines städtebaulichen Problems zu verstehen und gemeinsam im interdisziplinären Team Lösungen zu erarbeiten
- verschiedene städtebauliche Interessen zu verstehen und Aushandlungsvorschläge zu machen
- Fachdisziplinübergreifend Perspektiven zu wechseln und Projektmanagement in interdisziplinärer Teamarbeit anzuwenden
- verschiedene Methoden für die städtebauliche Analyse und Entwurf anzuwenden
- Umfang und Komplexität der Arbeit von interdisziplinären Forschungsprojekten mit hohem Partizipationsanteil zu verstehen

### **Teaching and Learning Methods:**

- Studium und Präsentation relevanter Case-Studies
- Vermitteln von methodischem Wissen mittels Input-Vorträgen
- Kooperationsformen in interdisziplinären Reallaboren mittels Best-Practice Beispielen und Input-Vorträgen
- Arbeit in interdisziplinären Teams

### **Media:**

- Zeichnungen (Handzeichnungen, CAD) auf verschiedenen Papierarten
- Beamerpräsentationen
- Bildliche Darstellungen (Handzeichnungen, CAD, Fotografie)
- physische Modelle

### **Reading List:**

A. Benze, Alltagsorte in der Stadtregion: Atlas experimenteller Kartographie Taschenbuch, 2012  
C. Bock, Das Kotti-Prinzip: Urbane Komplizenschaften zwischen Räumen, Menschen, Zeit, Wissen und Dingen Broschüre, 2018  
J. Gehl, Cities for People, 2010  
J. Gehl, How to Study Public Life: Methods in Urban Design Gebundene Ausgabe – Illustriert, 2013  
J. Jacobs, The Death and Life of Great American Cities, 1962  
M. Lydon & A. Garcia, Tactical Urbanism, 2015  
Professur Kees Christiaanse, Die Stadt als Ressource, 2014

### **Responsible for Module:**

Prof. Benedikt Boucsein

### **Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ6407: Urban Ecology | Ökologische Stadtentwicklung

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assignment consists of a presentation (15 min) with a written report (appr. 20 pages). Students demonstrate in their presentation understanding of the tasks of urban ecology and knowledge of urban ecological theories and methods. They are able to apply this knowledge in a case study to develop a strategic approach for ecologically oriented urban planning for a chosen topic.

#### Repeat Examination:

Next semester / End of Semester

#### (Recommended) Prerequisites:

Basic knowledge in landscape ecology and landscape planning are an advantage but no prerequisites.

#### Content:

Cities are good for people – but are they also good for the planet? The module explores the potentials for ecological restructuring and sustainable development of cities focussing on the role of the urban landscape. The module is comprised of a series of lecture and a seminar. It introduces knowledge and methods of urban ecosystem research and urban ecological planning. The module may comprise the following topics: Challenges of global urbanisation for urban ecology, theory and principles of urban ecological planning; management of urban metabolism and resources (urban climates, water, soils and biodiversity), adaptation of cities to climate change, green infrastructure planning, green compact cities, ecological restructuring of shrinking cities, urban agriculture, urban forestry, community involvement.

#### Intended Learning Outcomes:

On successful completion of the module, participants should:

1. understand core theories and methods of urban ecology

2. understand and have acquired knowledge on important tasks for urban ecology in urban development such as planning for urban climates, local stormwater management, soil protection, biodiversity, and climate change adaptation
3. be able to analyse and assess strategies for urban ecological planning
4. be able to transfer and apply ecological theories and methods in a project exercise for developing a strategy for urban ecological development

**Teaching and Learning Methods:**

The module is comprised of a lecture series and a seminar. The lecture series introduces knowledge on urban ecology with regards to topics such as: ecological challenges of urbanisation; urban landscapes and their ecosystem services; urban soils and their protection; urban climates; climate change adaptation; water; urban metabolism. The seminar aims to transfer this knowledge for developing an ecological strategy at the neighbourhood scale. To this end, the seminar is offered as a project work for small groups.

**Media:**

Powerpoint, modelling software, exercise sheets

**Reading List:**

Literature:

Niemelä J. et al., 2011. Handbook of Urban Ecology. Oxford University Press , Oxford, UK.

Further thematic reading will be made available in connection with the lectures and the seminar

**Responsible for Module:**

Stephan Pauleit [pauleit@wzw.tum.de](mailto:pauleit@wzw.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Seminar zur ökologischen Stadtentwicklung (Seminar, 2 SWS)

Pauleit S

Ökologische Stadtentwicklung (Vorlesung, 2 SWS)

Pauleit S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Field of Study 7: Environmental Geotechnics | Vertiefung 7: Environmental Geotechnics

### Required Modules | Pflichtmodule

#### Module Description

### BGU50007: Ground Water Handling and Sustainable Use of Geomaterials in Civil Construction | Grundwassermanagement und nachhaltige Materialverwendung in der Geotechnik

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written test of 90 minutes duration. The exam consists of theoretical questions, as well as calculations and design tasks. All study documents, simple scientific calculators and literature are permitted as an aid in the examination.

Through theoretical questions, the students demonstrate that they have understood complex geotechnical groundwater problems and the importance of tailings with regard to geotechnical and environmental challenges as well as different hydraulic failure mechanisms, including the failure of tailings. The calculation and design tasks on the basis of given geotechnical examples are used to verify that the students are able to use calculation approaches for the solution of geotechnical groundwater problems as well as methods for dealing with industrial by-products, RC-materials and other materials in earthworks, taking into account geotechnical and environmental aspects. They also show that they can develop solutions to minimize the impact of construction measures on the groundwater as well as concepts for dealing with difficult soil conditions in earthworks.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basics in geotechnical engineering and soil mechanics on a bachelor's level

### **Content:**

- Theory of groundwater flow in porous media and rock
- Hydrogeological site investigation
- Determination of hydraulic permeability of soils (field and lab tests)
- Methods of groundwater lowering (horizontal and vertical gravity wells, vacuum well, electroosmosis, water well design and construction)
- Suffosion, erosion, clogging, hydraulic failure
- Impact of building activities on groundwater level, groundwater bypass
- Effects of groundwater lowering
- Determination of design groundwater level
- Groundwater protection in transport infrastructure
- Geothermal energy (thermal properties of soils, shallow and deep geothermal energy systems)
- Sustainable use of geomaterials: Problem definition, regulations and legal aspects, geotechnical and environmental site investigation, aspects of characterisation of recycled materials and industrial by-products, mechanical and hydraulic properties of recycled materials and industrial by-products, use of slightly contaminated soils and recycled construction materials in earth works, use of problematic soils in earth constructions
- Tailings: general aspects, stability of tailings, environmental aspects and rehabilitation

### **Intended Learning Outcomes:**

After participating in the module the student is able to

- apply a deepened knowledge for geotechnical groundwater problems
- create solutions to minimize the impact of building constructions and activities on groundwater
- create systems for groundwater lowering
- evaluate different types of hydraulic failure of soil structures
- apply a deepened knowledge concerning the handling of mineral waste and recycled construction materials.
- create a modern mass flow management for soil and other earthworks materials considering geotechnical and environmental aspects
- create suitability proof concepts for difficult earthworks materials
- understand the geotechnical and environmental relevance of Tailings
- analyse typical failure mechanisms of Tailings

### **Teaching and Learning Methods:**

The module consists of a lecture.

In the lectures, the theoretical basics, for example groundwater movements, the hydrogeological investigation of building grounds and the measures to influence the groundwater movements, are presented, supported by pictures, films and discussions. Calculation examples from practice-oriented geotechnical engineering tasks provide the quantitative methods for the calculation of relevant groundwater problems in earthworks as well as for the conception of measures for their influence.

All lecture material is provided via the e-learning platform Moodle.

The voluntary weekly colloquium serves as an additional supportive offering for students.

**Media:**

Lecture notes, overhead-/PowerPoint presentation, blackboard

**Reading List:**

VOGT, N. lecture notes "Studienunterlagen Grundbau und Bodenmechanik"

**Responsible for Module:**

Dr.-Ing. Emanuel Birle e.birle@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Kolloquium zu Grundwassermanagement und nachhaltige Materialverwendung in der Geotechnik  
(Kolloquium, 1 SWS)

Birle E

Grundwassermanagement und nachhaltige Materialverwendung in der Geotechnik (Vorlesung, 4  
SWS)

Birle E, Lypp B, Pena Olarte A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU50008: Geotechnical Issues in Environmental Engineering | Geotechnische Fragestellungen im Umweltingenieurwesen

Version of module description: Gültig ab winterterm 2017/18

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written test of 90 minutes duration. The exam consists of theoretical questions, as well as calculations and design tasks. All study documents, simple scientific calculators and literature are permitted as an aid in the examination.

Theoretical questions on the basis of current environmental geotechnical questions show that the students can understand and present the current legal framework in the field of solid waste disposal, special aspects of the development of opencast landfills as well as relevant technical applications (e.g. suitability of different materials for isolating systems in landfill construction, possibilities for use of recycled materials in environmental geotechnics, methods for the remediation of contaminated sites). Through the calculation and design tasks the students demonstrate that they can apply the basics of water movement in saturated and unsaturated soils for boundary value problems in environmental geotechnical engineering, as well as to design and implement methods for the elimination of old open-castings and methods for soil improvement of open-cast fillings.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Knowledge in geotechnics, environmental geotechnics and soil mechanics on a bachelor's level

#### Content:

- Fundamentals of soil mechanics: Flow of water in saturated and unsaturated soils
- Handling of mineral waste

- Geotechnical design of landfill sites: engineered landfill, base and surface sealing systems, mineral liners, geosynthetic clay liners, geomembranes, transport of contaminants, mechanical properties of waste, stability of landfill bodies, water balance, subsequent use of covered landfills
- Building on fill: mechanical properties of fill materials, ground improvement
- Reutilisation of mineral waste: characterisation of mineral waste and industrial by-products, earth works with mineral waste, technical safeguards for the use of mineral waste in earth constructions
- Remediation of polluted land and abandoned landfills: contaminants, site investigation, remediation by treatment, remediation by containment
- Land reclamation
- Coastal protection

### **Intended Learning Outcomes:**

After participating in the module the students are able to

- to analyse the flow of water in saturated and unsaturated soils
- to evaluate the function of different sealing types for landfills
- to create suitable sealing systems for landfills
- understand the common legal framework for landfill constructions
- apply fundamental knowledge concerning the construction of landfill sites
- evaluate the usage of recycling-construction materials
- evaluate different methods for the remediation of polluted land and abandoned landfills
- evaluate ground improving methods with respect to their applicability for fill material

### **Teaching and Learning Methods:**

The module consists of a lecture.

In the lectures, the theoretical basics, for example the water movement in saturated and unsaturated soils, the landfill sealing systems or the characteristics of different geomaterials, are presented, supported by pictures, films and discussions. Calculation examples from practical environmental geotechnical tasks provide the quantitative methods for the calculation of water movements, for boundary value problems in geotechnics, as well as for the design of measures for landfill isolation and for the remediation of contaminated sites.

All lecture material is provided electronically via the e-learning platform Moodle. In addition, a voluntary colloquium is offered. In the colloquium, students' questions regarding the lecture content are discussed.

### **Media:**

Lecture notes, overhead-/PowerPoint presentation, blackboard

### **Reading List:**

lecture notes "Studienunterlagen Grundbau und Bodenmechanik"

GDA-Empfehlungen Geotechnik der Deponien und Altlasten, DGGT <http://www.gdaonline.de/empfehlung.html>

Verordnung über Deponien und Langzeitlager vom 27.04.2009

FGSV: Merkblatt über Bauweisen für Technische Sicherungsmaßnahmen beim Einsatz von Böden und Baustoffen mit umweltrelevanten Inhaltsstoffen im Erdbau (MTSE), Ausgabe 2008



LAGA: Anforderungen an die stoffliche Verwertung von mineralischen Abfällen - Technische Regeln - Allgemeiner Teil, 2003

LfU-Deponie-Info - Merkblatt 1: Mineralische Deponieabdichtungen, 2009

FGSV: Richtlinien für bautechnische Maßnahmen an Straßen in Wasserschutzgebieten (RiStWag), 2002

**Responsible for Module:**

Dr.-Ing. Emanuel Birle [e.birle@bv.tum.de](mailto:e.birle@bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Kolloquium zu Geotechnische Fragestellungen im Umweltingenieurwesen (Kolloquium, 1 SWS)  
Birle E

Geotechnische Fragestellungen im Umweltingenieurwesen (Vorlesung, 4 SWS)

Birle E, Cudmani R, Vogt S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Elective Modules | Wahlmodule

### Module Description

#### **BGU50018: Soil Dynamics and Geotechnical Earthquake Engineering with Project Work | Bodendynamik und geotechnisches Erdbebeningenieurwesen mit Projektarbeit [Soil Dynamics and Geotechnical Earthquake Engineering with Project Work]**

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination consists of a Project Work on a selected topic in Soil Dynamics and Geotechnical Earthquake Engineering. The project work consists of a written report (approx. 20 pages) and a final presentation (approx. 20 minutes).

The project work is carried out in groups of 2-3 students. The project work is developed in the following phases. At the beginning the problem has to be analyzed and evaluated. In doing so, the students demonstrate that they are able to comprehensively investigate questions from soil dynamics and geotechnical earthquake engineering and to apply learned structures to similar situations. Then strategies for solving the problem are to be developed and applied. In this way, the students show that they are able to independently develop problem-specific solutions from the learned structures by combining different methods. To support the students, regular meetings with the supervisor take place during the development of the project work. The project work ends with a presentation followed by a discussion with which the students demonstrate that they can present the results they have developed to a specialist audience and discuss them with them. In addition, the individual part of the individual is checked.

The final grade will consist out of the submitted written work (60%) and the presentation (40%).

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

The following modules (or equivalent modules) should be passed: (Notice: The contents of the modules can be found in the respective module manuals (handbooks).)

- Technical Mechanics I (BV000001)
- Technical Mechanics II (BV000004)
- Advanced Mathematics I (MA9517)
- Advanced Mathematics II (MA9512)
- BV000019 and BV500006: Foundation Engineering and Soil Mechanics Base & Supplementary Module (mandatory)
- BV430006: Soil Vibrations - Emission, Propagation, Immission, Abatement (recommended)

### **Content:**

The module deals with the following topics from the field of soil dynamics and geotechnical earthquake engineering

- Behaviour of soil under cyclic, alternating and dynamic loading
- Dynamic vs. monotonic soil behaviour
- Constitutive model to describe soil behaviour under cyclic and dynamic load
- Evaluation of dynamic soil behaviour by means of laboratory and field tests
- Dynamic foundation stiffness
- Wave propagation in elastic and elastoplastic mediums
- Seismic hazard
- Ground response analysis, local site effects and design ground motions
- Soil compaction due to earthquake loading
- Soil liquefaction during earthquakes
- Seismic stability of slopes
- Seismic design of shallow foundations, pile foundations and retaining walls
- Geotechnical aspects of the seismic codes (DIN 4149, Eurocode 8, Uniform Building Codes)
- Fundamentals of dynamic soil-structure-Interaction
- Dynamic penetration of piles

### **Intended Learning Outcomes:**

After successful completion of the module, the students should be able to:

- choose appropriate laboratory and field tests for the investigation of the cyclic behaviour of soils
- calculate the seismic site response with equivalent linear and non-linear wave propagation models, in the frequency and time domain,
- assess the liquefaction susceptibility of soils as a function of the expected earthquake intensity based on laboratory and field tests using empirical and numerical methods,
- design retaining walls, shallow and deep foundations to support seismic loads,
- apply advanced numerical methods to solve non-linear soil-structure interaction problems including dynamic loading.
- describe and critically evaluate a current topic in soil dynamics and geotechnical earthquake engineering in an academic and independent way
- apply the composition of proficient and comprehensive academic texts
- implement an independent task disposition (time management)

### **Teaching and Learning Methods:**

The module consists of a lecture and a colloquium accompanying the project work. In the lecture, the theoretical basics of soil behavior under dynamic stimulation and the special features that have to be taken into account when planning engineering structures in connection with dynamic loads are conveyed. The PowerPoint slides shown are made available to the students as printouts.

The project work is largely carried out independently by the students. The project work serves to deepen the topics of soil dynamics and geotechnical earthquake engineering based on a specific question.

Regular supervision and progress monitoring are carried out by the respective supervisor. This learning method promotes, among other things, an independent way of working for students. In the end, the results will be presented to all participants and discussed with them.

### **Media:**

Lecture notes, overhead-/PowerPoint presentation, blackboard

### **Reading List:**

Geotechnical Earthquake Engineering, KRAMER S., Prentice Hall, 1996.

Geotechnical Earthquake Engineering Handbook, DAY R. W., McGraw Hill, 2002.

Geotechnical Applications for earthquake engineering: Research Advancements, SITHARAM T.G., Information science reference, 2012.

Liquefaction of soils during earthquakes, Committee on earthquake engineering, National Academy Press, 1985.

Dynamic of Structures: Theory and applications to earthquake engineering, CHOPRA A.K., Prentice Hall of India, 2003.

DIN 4149:2005-04: „Bauten in deutschen Erdbebengebieten – Lastannahmen, Bemessung und Ausführung üblicher Hochbauten“, Beuth Verlag.

EN 1998-1: 2005 Eurocode 8: Design of structures for earthquake Resistance. European Committee for Standardization Brussels, Belgium, 2005.

Uniform Building Code (UBC), International Conference of Building Officials, Whittier, California, 1997.

### **Responsible for Module:**

Prof. Dr. Ing. Roberto Cudmani

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Projektarbeit zu Bodendynamik und geotechnisches Erdbebeningenieurwesen (Kolloquium, 2 SWS)

Chrisopoulos S

Bodendynamik und geotechnisches Erdbebeningenieurwesen (Vorlesung, 2 SWS)

Cudmani R, Chrisopoulos S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU50019: Earthworks and Building with Geosynthetics | Erd- und Dammbau und Bauen mit Geokunststoffen [Earthworks and Building with Geosynthetics]**

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination consists of a 90-minute written exam.

The written exam consists of general questions and free formulations. All study materials, literature and simple scientific calculators are accepted as aids. With the written exam, students demonstrate that they have developed an understanding of the basic principles of earthworks, dam construction and construction with geosynthetics as taught in the module. The answers focus on their own keyword formulations. In some cases, smaller calculations are required.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

- Foundation Engineering and Soil Mechanics Base & Supplementary Module (BV000019 and BV500006)
- Technical Mechanics I (BV000001)
- Technical Mechanics II (BV000004)
- Advanced Mathematics I (MA9517)
- Advanced Mathematics II (MA9512)

#### **Content:**

The module covers the following topics:

- Earthworks construction materials
- Construction operations
- Soil compaction
- Soil improvement and soil stabilization
- Cuttings and dams

- Backfillings
- Drainage layers
- Quality assurance
- functions of geosynthetics
- products
- investigations and testing methods
- installation, processing, loading
- examples of applications (embankment on weak subsoil, slopes and steep embankments, walls, road and railways)

### **Intended Learning Outcomes:**

After participating in the module the student is able to

- describe soil and rock as an earthworks construction material
- classify soil and rock as an earthworks construction material for tenderings
- classify soil and rock for structural purposes
- describe the fundamental relationships of the construction of earth and embankment structures
- analyze the introduced manufacturing processes
- optimizing construction processes in a problem-specific manner
- transfer soil mechanical knowledge into earth and embankment construction
- name various types of geosynthetics
- analyze their suitability according to the field of application.

### **Teaching and Learning Methods:**

The module consists of one lecture. In the lecture, the topics from the field of earthworks, dam construction and construction with geosynthetics are conveyed through lectures with constant support by a PowerPoint presentation and illustrated by the experiences of the lecturers in this field.

### **Media:**

lecture notes, Powerpoint-presentation, blackboard, films

### **Reading List:**

HEYER, lecture notes "Erd- und Dammbau"

VOGT, N. lecture notes "Studienunterlagen Grundbau und Bodenmechanik"

KOLYMBAS, D. (1998): Geotechnik - Bodenmechanik und Grundbau; Springer-Verlag (Univ. Innsbruck)

LANG, HUDER, AMANN (2003): Bodenmechanik und Grundbau, Springer Verlag (ETH Zürich)

SCHMIDT, H.-H. (2001): Grundlagen der Geotechnik Verlag Teubner

- Merkblatt über die Anwendung von Geokunststoffen im Erdbau des Straßenbaus, Ausgabe 2005, Forschungsgesellschaft für Straßen- und Verkehrswesen, Arbeitsgruppe Erd- und Grundbau, Köln, FGSV Heft Nr. 535

- Technische Lieferbedingungen für Geokunststoffe im Erdbau des Straßenbaus TL Geok E-StB 05

- Empfehlungen für Bewehrungen aus Geokunststoffen - EBGEO, hrsg. von der Deutschen Gesellschaft für Geotechnik e.V. (DGGT), Berlin, Ernst & Sohn Verlag, 2010
  - Schweizerischer Verband für Geokunststoffe, 2003, Handbuch Bauen mit Geokunststoffen
  - Geokunststoffe im Erd- und Straßenbau, 2. Auflage, Herausgeber: Müller-Rochholz, J., Oktober 2008
- Grundbau-Taschenbuch: Teile 1-3: Witt, Karl Josef (Hrsg.), Ernst & Sohn Verlag, 2018

**Responsible for Module:**

Lecture, 2SH, Dr.-Ing. Emanuel Birle, [manuel.birle@tum.de](mailto:manuel.birle@tum.de) Lecture, 2SH, Dipl.-Ing. Gerhard Bräu, [gerhard.braeu@tum.de](mailto:gerhard.braeu@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Erd- und Dammbau und Bauen mit Geokunststoffen (Vorlesung, 4 SWS)

Bräu G, Huber S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66024D2: Advanced Groundwater Modelling for Environmental Engineers | Fortgeschrittene Grundwassermodellierung für Umweltingenieure

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105   | <b>Contact Hours:</b><br>75                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a project work.

Students will complete a project work containing the analysis of given case studies on hydrogeological and hydraulic situations, subsurface contamination and related questions. This is to be done with help of mathematical modeling.

By exposing the students to defined “real world” hydrogeological cases, the project work measures the student’s competence to describe, analyze and evaluate hydrogeological problems with help of mathematical modeling. Students have to transfer and apply their knowledge obtained during the module. This includes an understanding of relevant processes in the soil-groundwater-plant system (water flow, contaminant transport and fate) and of interactions between groundwater and surface water. Adequate mathematical models have to be chosen and applied, and used models and model simulations have to be documented in the project work report. Based upon the model simulations, evaluations have to be done concerning hydraulic conditions and contaminant transport/fate in groundwater, soil and plants as well as concerning hydraulic interactions between groundwater and surface water. Obtained model simulations have also to be evaluated with respect to plausibility (comparison to available site information and measured data).

Project work will be done in groups. Each group has to accomplish a written report on the project work, and this report will be graded. The project work and report consists of two parts corresponding to the two courses. The report covers 20-30 pages in total. In order to recognize individual contributions, students shall document their contribution to subtasks within the project work and respective chapters of the report. The reports shall contain problem statements, results and findings concerning the case studies, as well as a discussion of the findings and a presentation of applied methods.

#### Repeat Examination:

Next semester



**(Recommended) Prerequisites:**

Basic understanding of Hydrogeology, Mathematics, Physics and Chemistry is recommended. Students should be interested in working with mathematical models. It is recommended that students have visited one of the following modules: BV660006 Hydrogeology I (Hydrogeologie I), BV660002 Groundwater Flow and Transport (Strömung und Transport).

**Content:**

This module deals on modeling hydrological and chemical processes in the soil-groundwater-plant system, as well as on modeling hydraulic exchange and feedback mechanisms between groundwater and surface water. Topics include:

Course Groundwater-Soil-Plant-Interaction:

- Soil and unsaturated zone (characteristics and processes)
- Plant physiology and functionality, plant-related processes in the environment
- Sorption and diffusion, microbes in the subsurface (microbial growth and degradation)
- Soil water balance and leaching, evaporation and transpiration, contaminant fate/transport in the unsaturated zone and within plants
- Set-up and application of analytical and water balance models for the soil-groundwater-plant system, for analyzing and evaluating water availability/flow and pollutant fate

Course Groundwater Modeling (Advanced):

- Contaminant transport in groundwater (processes and their mathematical description)
- Set-up and parameterization of analytical and numerical contaminant transport models, model application and interpretation of results
- Exchange and feedback mechanisms between groundwater and surface water and coupling of model codes
- Parameterization and application of the coupled groundwater-surface water model approach
- Evaluation of hydraulic situations with help of the simulation results

**Intended Learning Outcomes:**

A student who has met the objectives of the course will be able to:

- understand relevant processes in the soil-groundwater-plant system with respect to the water budget and contaminant transport and fate
- describe related environmental processes mathematically and develop baseline simulation models
- analyze hydraulic conditions and contaminant transport/fate in groundwater, soil & plants with help of modeling
- understand and evaluate hydraulic interactions between groundwater and surface water
- understand and apply the coupling of numerical surface water and groundwater models
- compare model calculations with observations and available site data and evaluate the obtained simulation results

**Teaching and Learning Methods:**

The module consists of two lectures with integrated exercises. The underlying teaching philosophy of the module is problem-based learning. The core of the courses consists of a series of tutorials,

which should expose the students to important questions, problems and methodologies. The tutorials are supported by lectures, discussion and focused reading.

Each of the scientific topics will be trained and discussed for one to three weeks with lectures and tutorials. Each topic will be started with a thematic refresher and a lecture. After the lecture there will be a tutorial, and this tutorial trains the students' expertise by having 'hands-on'. This means students are working on the tutorials in class (computer room) in order to actively learn on formulating and solving problems in the field of hydrogeology, groundwater-soil-plant interactions, groundwater-surface water interactions and subsurface contamination.

At the final part of the two courses (the last one or two sessions), case studies on hydraulic situations and subsurface contamination to be analyzed will be handed out (project work). Students will start with the project work in groups under supervision, where feedback will be given to each group by one-to-one discussions during the contact hours. Each group has to accomplish a written report on the project work at the end of the module (details see above). Working in groups trains the students' competence to carry out and complete their task (solving a hydrogeological problem) in a team. Individual contributions shall nonetheless be recognizable: students shall document their contribution to subtasks within the project work, reflected in respective chapters of the report.

**Media:**

Moodle e-learning platform, presentations, exercise hand-outs, pc-lab, recommended literature

**Reading List:**

Scheffer F, Schachtschabel P (2010): Lehrbuch der Bodenkunde. Springer, Berlin. (Older editions: Enke, Spektrum).

Trapp S, Matthies M (1998): Chemodynamics and Environmental Modeling: An Introduction. Springer, Berlin (German edition: Dynamik von Schadstoffen - Umweltmodellierung mit CemoS: Eine Einführung. Springer, Berlin, 1996)

Trapp S, McFarlane JC (1995): Plant Contamination. Lewis Publishers, London.

Holzbecher E (1996): Modellierung dynamischer Prozesse in der Hydrologie - Grundwasser und ungesättigte Zone. Springer, Berlin.

Schwarzenbach RP, Gschwend PM, Imboden DM (2002): Environmental Organic Chemistry. 2.Ed., Wiley, New York.

Anderson, M., Woessner, W. (1992): Applied Groundwater Modelling. Academic Press, Inc.

Kinzelbach, W. & Rausch, R. (1995): Grundwassermodellierung – Eine Einführung mit Übungen. Borntraeger, Stuttgart.

Kovarik, K. (2000): Numerical Models in Groundwater Pollution. Springer, Berlin.

Rausch, R., Schäfer, W. & Wagner, Ch. (2002): Einführung in die Transportmodellierung im Grundwasser. Borntraeger, Stuttgart.

**Responsible for Module:**

Arno Rein, arno.rein@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrogeologische Fallbeispiele, Grundwasser-Boden-Pflanzen-Interaktion (Vorlesung mit integrierten Übungen, 2 SWS)

Rein A

Grundwassermodellierung (Fortgeschrittene) (Vorlesung mit integrierten Übungen, 3 SWS)

Zoßeder K, Rein A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66041: Contaminant Transport and Remediation | Transport und Sanierung von Schadstoffen [ContTransRemed]

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

At the end of the module, students participate in a written exam of 120 minutes duration. The exam will focus on the physical and chemical processes underlying contaminant transport and environmental remediation strategies and on the development of related computer models. The exam will verify that the students understand the principles to plan and carry out remediation of contaminated soils and water bodies. Furthermore, it will verify that the students understand basic concepts of environmental chemistry and pollutant transport in the environment and that the students are able to apply those concepts for the solution of problems within a given period of time. The exam will consist of open questions, multiple choice questions and exercises which will require short computations. In knowledge and transfer questions, the students demonstrate both their theoretical knowledge in pollutant hydrogeology and their ability to interpret and evaluate scientific measurement results quantitatively, to develop a prediction for mass dispersion in given exemplary scenarios and to clearly present and visualise the results, e.g. in schematic sketches and cross sections. No auxiliary material is allowed during the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in hydrology, hydrogeology and environmental chemistry (e.g., the MSc module Case studies in technical hydrogeology)

#### Content:

Students acquire the necessary knowledge and skills to quantitatively describe and evaluate the transport of pollutants in groundwater.

- Legal bases for the quality of groundwater and surface water

- Transport of water constituents in saturated and unsaturated environments (dispersion, sorption, degradation)
- Multiphase flow,
- Reactive mixing in surface water bodies
- Colloid transport,
- Transport properties of inorganic and organic contaminants
- General introduction on fate and transport of contaminants in the environment
- Analytical and numerical modeling of reactive solute transport
- Principles of in situ chemical oxidation
- Remediation technology for the unsaturated zone
- Land management

### **Intended Learning Outcomes:**

After participating in the module, the students are able to

- to quantify the spread of pollutants in groundwater and assess the risk of groundwater contaminations in a pollutant-specific way.
- to understand the effects of technical measures (e.g. iron removal, hardening, chlorination) in water treatment on the behaviour of pollutants and to transfer this knowledge to other issues (e.g. mixing of near-surface groundwater with deep groundwater)
- to understand the basic processes controlling commonly applied environmental remediation strategies
- to predict the effectiveness of different remediation strategies

The main objective of the moodle based modeling exercises is to enable students to understand, apply and further develop models to plan, predict and carry on remediation actions.

### **Teaching and Learning Methods:**

The module consists of two lectures. The teaching philosophy behind this module is based on the evidence that different study goals will be achieved using different approaches. The theoretical lectures' contents are presented by the lecturer using both the blackboard and digital slides. The students will get familiar with the subject solving independently relevant practical problems. Additionally, modelling exercises are offered on Moodle (asynchronous), with which the students train their programming skills

### **Media:**

Presentations (beamer/blackboard) , case studies in teams, exercise on e-learning platform

### **Reading List:**

- Kitanidis, P. K. and McCarty, P.L. (2012), Delivery and mixing in the subsurface: Processes and Design Principles for in situ remediation
- Siegrist et al. (2011), In Situ chemical oxidation for groundwater remediation
- Schoor J.L. (1996), Environmental Modeling fate and transport of pollutants in water, air and soil
- Appelo C.A.J, Postma, D. (2006) Geochemistry, Groundwater and Pollution, Balkema, Leiden.
- Clark & Fritz (1997): Environmental Isotopes in Hydrogeology.-398 S. Lewis Publisher.
- Domenico, Schwartz(1998): Physical and chemical hydrogeology.- (Wiley).

Fetter (2001): Applied Hydrogeology.- New Jersey (Prentice-Hall).

Fetter, Boving, Kreamer (1998): Contaminant Hydrogeology, Long Grove (Waveland Press)

Matthess, G. (1994): Die Beschaffenheit des Grundwassers.- 499 S.; Berlin

**Responsible for Module:**

Prof. Dr. Thomas Baumann

**Courses (Type of course, Weekly hours per semester), Instructor:**

Transport von Schadstoffen im Grundwasser (Vorlesung, 2 SWS)

Baumann T

Environmental Remediation Strategies (Vorlesung, 2 SWS)

Chiogna G [L], Chiogna G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU67001: Landslides | Hangbewegungen

Version of module description: Gültig ab summerterm 2013

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

credit requirement: unsplit examination with pocket calculator and formulary; pass/fail credit requirement: 3 days mandatory field trips (3 x 8 h), protocol, not graded.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

As-built surveys and geodetical monitoring, fundamentals of geology

#### Content:

- Definition, terms & classification
- Landslide types and processes
- Landslide causes and triggers
- Case studies Goldau, Rufi, Grätli, Vajont, Elm
- Investigation and analysis of landslides
- Mapping of phenomena, Hazard & risk maps
- Monitoring techniques, early warning systems
- Case study Sudelfeld, research project alpEWAS
- Remote sensing reconnaissance
- Principles of risk assessment for natural hazards
- Assessing the probability of landslide hazards
- Vulnerability and exposure to landslide hazards
- Cost-benefit optimization of mitigation measures
- Landslide risk communication and management

- Mitigation measures
- Geodetical monitoring
- Concepts, instrumentation, processing
- European case studies (alpine landslides)
- North American case studies (coastal landslides)
- Case studies from developing and emerging countries

### **Intended Learning Outcomes:**

After the course, students are familiar with different types of landslides and are able to classify and describe landslides types and processes on an international approved level. Students will be able to differentiate causes and triggers of a landslide and to analyse different movement and transportation types. They will be able to select the appropriate investigation techniques for monitoring and to apply hazard mapping and zoning techniques. The students will know and understand the principles of risk assessment and management for landslides and other gravitational natural hazards. They will be able to conduct and interpret basic risk analyses and cost-benefit optimization of landslide mitigation measures.

### **Teaching and Learning Methods:**

The course will consist of 3 lectures. The lectures include videos, slide shows and demonstrations of processes. There will be mandatory exercises and optional field days showing various landslide case studies which have been discussed during the lectures.

### **Media:**

Powerpoint presentation, viewgraphs, blackboard, videos, lecture notes, field trip

### **Reading List:**

- TURNER and SCHUSTER: Landslides: Investigation and Mitigation, National Academy Press, 1996
- CENAT: Dealing with natural hazards and risks, module 3 landslides, web-based lectures, Kompetenzzentrum Naturgefahren der Schweiz CENAT, ETH Zürich
- DUNNICLIFF: Geotechnical instrumentation for monitoring field performance, Wiley, 1993
- SCHOFIELD & BREACH: Engineering Surveying, sixth edition, Elsevier, 2007



- BONNARD, FORLATI & SCAVIA: Identification and Mitigation of Large Landslide Risks in Europe
- Advances in Risk Assessment, European Commission Fifth Framework Programme, IMIRILAND Project, Balkema Publishers, 2004

- ClimChAlp (CLIMATE CHANGE, IMPACTS AND ADAPTATION STRATEGIES IN THE ALPINE SPACE): Slope Monitoring Methods - State of the Art Report, 2008 [http://www.geo.bv.tum.de/images/stories/dokumente/climchalp\\_-\\_work\\_package\\_6\\_report.pdf](http://www.geo.bv.tum.de/images/stories/dokumente/climchalp_-_work_package_6_report.pdf)

**Responsible for Module:**

Kuroschi Thuro (thuro@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geodetic Monitoring of Landslides (Vorlesung, 1 SWS)

Holst C, Raffl L

Landslides - Recognition, Investigation & Mitigation Measures (Vorlesung, 2 SWS)

Krautblatter M, Holst C, Straub D, Kiefer C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV120003: Earthworks and Embankments | Erd- und Dammbau

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written, open book test of 60 minutes duration. All study documents, literature and a simple scientific pocket calculator are permitted as aids.

The examination consists of general theoretical questions and calculations. By means of the general questions, the students demonstrate their ability to describe soil and rock as an earth-building-material, to analyze and classify their structural properties, and to evaluate these in terms of suitability for various construction processes for dams and dikes. On the basis of calculations, the students show that you are able to optimize construction methods as well as transfer soil mechanics knowledge to the construction of earthworks and embankments.

#### Repeat Examination:

#### (Recommended) Prerequisites:

The following modules should be passed: (Notice: The contents of the modules can be found in the respective module manuals (handbooks).)

- Foundation Engineering and Soil Mechanics Base & Supplementary Module (BV000019 and BV500006)
- Technical Mechanics I (BV000001)
- Technical Mechanics II (BV000004)
- Advanced Mathematics I (MA9517)
- Advanced Mathematics II (MA9512)

#### Content:

- Earthworks construction materials
- Construction operations
- Soil compaction

- Soil improvement and soil stabilization
- Cuttings and dams
- Backfillings
- Drainage layers
- Quality assurance

**Intended Learning Outcomes:**

After participating in the module the student is able to

- describe soil and rock as an earthworks construction material
- classify soil and rock as an earthworks construction material for tenderings
- classify soil and rock for structural purposes
- describe the fundamental relationships of the construction of earth and embankment structures
- analyze the introduced manufacturing processes
- check and critique construction methods
- create quality management processes
- transfer soil mechanical knowledge into earth and embankment construction

**Teaching and Learning Methods:**

The lecture is intensively assisted by a PowerPoint presentation, whereby the students can directly profit from the experience of the lecturer. The PowerPoint-Slides are prepared for the students and are provided as print-outs in the lecture, as well as in digital form via the e-learning platform Moodle for follow-up purposes.

**Media:**

lecture notes, Powerpoint-presentation, blackboard, films

**Reading List:**

HEYER, lecture notes "Erd- und Dammbau"

VOGT, N. lecture notes "Studienunterlagen Grundbau und Bodenmechanik"

KOLYMBAS, D. (1998): Geotechnik - Bodenmechanik und Grundbau; Springer-Verlag (Univ. Innsbruck)

LANG, HUDER, AMANN (2003): Bodenmechanik und Grundbau, Springer Verlag (ETH Zürich)

SCHMIDT, H.-H. (2001): Grundlagen der Geotechnik Verlag Teubner

**Responsible for Module:**

Akad. Dir. Dr.-Ing. Dirk Heyer, [dirk.heyer@tum.de](mailto:dirk.heyer@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Erd- und Dammbau (Vorlesung, 2 SWS)

Heyer D, Bock B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV120008: Soil Mechanics Lab | Bodenmechanisches Praktikum

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written, closed book exam of 60 minutes duration. Auxiliaries are not allowed.

Through theoretical questions the students prove that they are able to name the main parameters in soil mechanics, explain the theoretical background of soil mechanics experiments and describe the performance and evaluation of those experiments. The questions require mainly descriptive answers in form of bullet points. Sometimes smaller calculations are required.

#### Repeat Examination:

#### (Recommended) Prerequisites:

The following modules should be passed: (Notice: The contents of the modules can be found in the respective module manuals (handbooks).)

- Foundation Engineering and Soil Mechanics Base & Supplementary Module (BV000019 and BV500006)
- Technical Mechanics I (BV000001)
- Technical Mechanics II (BV000004)
- Advanced Mathematics I (MA9517)
- Advanced Mathematics II (MA9512)

#### Content:

- Field tests
- Determination of soil density in the lab
- Proctor test
- Water permeability test
- Compression test

- Shear Box test
- Triaxial test

**Intended Learning Outcomes:**

Upon successful completion of the module, students are able to

- know the main parameters of soil mechanics
- understand the theoretical background to soil mechanics experiments
- describe and carry out experiments
- evaluate experimental results

**Teaching and Learning Methods:**

The shown tests take part in the laboratory of the "Zentrum Geotechnik" in 81245 Munich-Pasing and are practically oriented. After a short theoretical introduction with the aid of a PowerPoint presentation for each test, whereby the students can directly profit from the experience of the lecturer, the students conduct the experiments in small groups independently in the lab. Thereby the results are noted into form sheets, which are then handed out to all of the students for voluntary evaluation.

**Media:**

lab equipment, lecture notes, Powerpoint-presentation

**Reading List:**

VOGT, N. lecture notes "Studienunterlagen Grundbau und Bodenmechanik"

KOLYMBAS, D. (1998): Geotechnik - Bodenmechanik und Grundbau; Springer-Verlag (Univ. Innsbruck)

LANG, HUDER, AMANN (2003): Bodenmechanik und Grundbau, Springer Verlag (ETH Zürich)

SCHMIDT, H.-H. (2001): Grundlagen der Geotechnik Verlag Teubner

**Responsible for Module:**

Sven Manthey M.Sc., s.manthey@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Bodenmechanische Laborübung (Übung, 2 SWS)

Uday A, Zeni M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV150050: Environmental Geology / Geochemistry | Umweltgeologie / Geochemie

Version of module description: Gültig ab summerterm 2011

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>75   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Prüfungsdauer (in min.): 60.

schriftliche Prüfung

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Basics of geology; organic and inorganic chemistry

#### Content:

- Formation of elements and chemical composition of the crust and igneous rocks
- Aqueous solubility, weathering and geochemistry of natural waters
- geochemical effects of natural colloids
- acid mine/rock drainage, microbial processes, and remediation
- use of stable and radiogenic isotopes in environmental research
- environmental radioactivity
- origin, transport and biological uptake of toxic organic compounds
- particulates, mineral dusts, air pollutants, greenhouse gases, paleoclimate and carbon storage

#### Intended Learning Outcomes:

At the end of the module students are able

- to remember inorganic and organic natural and anthropogenic pollutants
- to understand the basic principles and processes related to distribution, transport and attenuation of hazardous elements in natural environments
- to design and assess isotope studies in environmental problems
- to evaluate the environmental risk of ores and mining wastes and plan remediation concepts

**Teaching and Learning Methods:**

The module is principally a lecture with power point presentations and black board writing. Important working materials such as figures and tables are accessible on-line. For a better learning outcome instructive demonstration materials (rock samples) are shown and given to the students. Some exercises are presented for homework.

**Media:**

powerpoint presentation; geological hands-on samples for illustration; handouts with important figures and tables

**Reading List:**

EBY GN (2003) Principles of Environmental Geochemistry, Brooks Cole.

SHERWOOD LOLLAR B (2005) Environmental Geochemistry (Treatise on Geochemistry, Vol.9), Elsevier.

LANGMUIR D (1997) Aqueous Environmental Geochemistry, Prentice Hall.

**Responsible for Module:**

Kuroschi Thuro (Thuro@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Environmental Geology / Geochemistry (Vorlesung, 2 SWS)

Gilg H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV500003: Unsaturated soil mechanics | Mechanik ungesättigter Böden

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Proof of performance takes place in the form of a 60 minute written exam.

The exam consists of general questions with unrestricted formulations. Aids including all lecture notes, literature and a basic academic calculator are allowed. It will be proven, that the students have developed an understanding for the conveyed fundamental relationships of unsaturated soil mechanics within the scope of the module. The focus of the answers lies on individual shorthand formulations. In part, small calculation problems must also be solved.

#### Repeat Examination:

#### (Recommended) Prerequisites:

The following modules should be passed: (Notice: The contents of the modules can be found in the respective module manuals (handbooks).)

- Foundation Engineering and Soil Mechanics Base & Supplementary Module (BV000019 and BV500006)
- Technical Mechanics I (BV000001)
- Technical Mechanics II (BV000004)
- Advanced Mathematics I (MA9517)
- Advanced Mathematics II (MA9512)

#### Content:

- Introduction to the principles of unsaturated soil mechanics
- total, matric and osmotic suctions
- determination of the suction tension-water content relationship of soils
- determination of hydraulic conductivity in unsaturated states
- models for the description of the suction tension-water content relationship
- models for the description of hydraulic conductivity



- description of water flow in unsaturated soils
- effective stresses in unsaturated soils
- volume change behaviour of unsaturated soils
- shear strength of unsaturated soils
- importance of unsaturated soil mechanics for design in geotechnical engineering

**Intended Learning Outcomes:**

After participating in the module the student is able to

- evaluate the soil-mechanical behaviour of unsaturated soils
- devise experimental investigations to be able to determine the soil-mechanical properties of unsaturated soils
- apply the basics of water flow in unsaturated soils
- use models to describe the stress propagation in unsaturated soils and shear strength of unsaturated soils
- evaluate geotechnical problems in unsaturated soils

**Teaching and Learning Methods:**

The lecture is intensively assisted by a PowerPoint presentation, whereby the students can directly profit from the experience of the lecturer. Films and pictures concerning experiments and procedures are integrated. It is possible to deepen the lecture material with the aid of voluntary exercise questions.

**Media:**

lecture notes, Powerpoint-presentation, blackboard, films

**Reading List:**

lecture notes

Lu, N. and Likos, W. J.: Unsaturated soil mechanics, Wiley Verlag, 2004

Fredlund, D. G. and Rahardjo, H.: Soil mechanics for unsaturated soils, Wiley Verlag, 1993

Mitchell, J. K. and Soga, K.: Fundamentals of soil behaviour, Wiley Verlag, 2005

**Responsible for Module:**

Dr.-Ing. Emanuel Birle, [emanuel.birle@tum.de](mailto:emanuel.birle@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Mechanik ungesättigter Böden (Vorlesung, 2 SWS)

Birle E, Bock B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ1647: Remediation of Contaminated Sites - Lecture and Exercises | Altlastensanierung - Vorlesung und Übungen

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung besteht aus einer schriftlichen Klausur (120 min). Anhand der Klausur zeigen die Studierenden, dass sie gesetzliche Regelungen, die sich mit Altlasten beschäftigen, verstehen, das Gefährdungspotential einer Altlast im Hinblick auf die Art der Schadstoffe und den Emissionspfad bewerten können, die verschiedenen Untersuchungsmethoden verstehen sowie eine geeignete Probenahmestrategie und analytisches Untersuchungsprogramm bewerten können.

Das Modul "Altlastensanierung - Vorlesung und Übungen" ist das Alternativmodul zu "Altlastensanierung - Vorlesung und Seminar". Je nach verfügbaren Plätzen behält sich der Modulverantwortliche vor, die Studierenden dem einen oder anderen dieser beiden Module zuzuordnen. Es kann nur eines von beiden Modulen absolviert werden.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Einführung in die Bodenkunde 1 und 2 müssen erfolgreich absolviert sein (Ausschlusskriterium).

#### Content:

Vorlesung: Bundesbodenschutzgesetz, Vorgehensweise bei der Erkundung von Altlasten; branchentypische Kontaminationen (Altablagerungen - Altstandorte, Rüstungs- und Militäraltlasten); Bewertung von Kontaminanten (Hauptkontaminanten - Prioritätskontaminanten, Stofftransport, Exposition); Gefährdungspotential, ökotoxikologische Tests; Untersuchung von Altlasten (Untersuchungsmethoden, Probenahmestrategie, analytisches Untersuchungsprogramm); Sanierungsziele; Sicherungsmaßnahmen; Dekontaminationsverfahren; Rekultivierung und Renaturierung (Böden auf Altstandorten, Bergbaufolgelandschaften).

Übungen: Besuch von Altlastenbetrieben im Raum München: Biologische ex-situ Sanierung organisch belasteter Böden; Beprobung kontaminierten Bodenmaterials in Haufwerken; Immissionsschutzvorgaben für altlastenbearbeitende Betriebe; Sortierung und (Zwischen-) Lagerung kontaminierter Böden vor der Entsorgung in geeigneten Deponien; LAGA Deponieklassen zur Klassifikation kontaminierter Böden; Verwertungsmöglichkeiten für kontaminiertes Material; innovative in-situ Sanierungs- und Sicherungsmaßnahmen; Verhältnis von Investitions- und Betriebskosten bei langfristigen Sanierungsmassnahmen; Sicherungsmaßnahmen in Bergbaufolgelandschaften; spezifische Probleme in Braunkohlentagebaufolgelandschaften; Evaluation von Rekultivierungs- und Renaturierungsmaßnahmen; gesetzliche Hintergründe: Bundesbodenschutz-, Kreislaufwirtschafts- und Wasserschutzrecht.

### **Intended Learning Outcomes:**

Nach erfolgreicher Teilnahme an den Modulveranstaltungen sind die Studierenden in der Lage, gesetzliche Regelungen, die sich mit Altlasten beschäftigen, zu verstehen, die richtige Vorgehensweise bei der Untersuchung von Altlasten und Altlastenverdachtsflächen sowie bei der Sanierung von Altlasten anzuwenden, das Gefährdungspotential einer Altlast im Hinblick auf die Art der Schadstoffe und den Emissionspfad zu bewerten, die verschiedenen Untersuchungsmethoden zu verstehen sowie eine geeignete Probenahmestrategie und analytisches Untersuchungsprogramm zu bewerten, unterschiedliche Sanierungstechniken und Rekultivierungsmaßnahmen zu bewerten und in Abhängigkeit von der jeweiligen Altlast die geeignete anzuwenden. Zudem sind die Studierenden in der Lage, verschiedene altlastenbearbeitende Betriebe und Altlastenstandorte zu bewerten sowie die angewandten Sanierungsverfahren kritisch, im Hinblick auf Sanierungserfolge und Umweltauswirkungen, zu analysieren.

### **Teaching and Learning Methods:**

Das Modul besteht aus einer Vorlesung und einer Übung. In der Vorlesung werden den Studierenden die gesetzliche Regelungen, die sich mit Altlasten beschäftigen, die richtige Vorgehensweise bei der Untersuchung von Altlasten und Altlastenverdachtsflächen sowie bei der Sanierung von Altlasten, das Gefährdungspotential einer Altlast im Hinblick auf die Art der Schadstoffe und den Emissionspfad, die verschiedenen Untersuchungsmethoden sowie eine geeignete Probenahmestrategie und analytisches Untersuchungsprogramm, unterschiedliche Sanierungstechniken und Rekultivierungsmaßnahmen vermittelt.

In den Übungen wird mit den Studierenden während des Besuchs ausgewählter belasteter Standorte und Sanierungseinrichtungen verschiedene altlastenbearbeitende Betriebe und Altlastenstandorte bewertet sowie die angewandten Sanierungsverfahren kritisch, im Hinblick auf Sanierungserfolge und Umweltauswirkungen, analysiert.

### **Media:**

Präsentationen

**Reading List:**

Präsentationen; vertiefende Bücherliste auf Anfrage

**Responsible for Module:**

Kögel-Knabner, Ingrid; Prof. Dr. rer. nat. Dr. rer. nat. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Remediation of Contaminated Sites - Regeneration of contaminated soils (Vorlesung, 2 SWS)

Bucka F

Altlastensanierung - Kontaminierte und rekultivierte Böden (Übung, 2,1 SWS)

Bucka F, Heister K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Field of Study 8: Environmental Hazards and Risk | Vertiefung 8: Environmental Hazards and Risk

### Required Modules | Pflichtmodule

#### Module Description

### BGU46026: Alpine Hazards | Alpine Naturgefahren [Ri+Kr]

#### *Alpine Hazards*

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written, closed book test of 120 minutes duration. It consists of theoretical questions, practical tasks and calculations. Only a simple scientific calculator and a dictionary are allowed aids.

In the exam, the students demonstrate by answering theoretical questions that they can explain the main processes in alpine watersheds and analyse them concerning the flows of water, debris, the influence on land mass movements and the resulting hazard potential. Furthermore, they show that they understand the working mechanisms of measures for hazard mitigation in mountainous regions. On the basis of practical examples, they show that they can analyse realistic situations and apply mitigation measures in targeted strategies for alpine hazards. Through calculation tasks they prove that they can assess the quantitative aspects of the hazard side and the measure side.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in Geology and Water Management.

#### Content:

Part 1: "Water Management in Mountain Regions"

The students get an introduction on the objectives and means of protective watershed management in alpine regions. The processes in natural landscapes, the relevant influencing factors on runoff and debris flow, the alpine water balance and relevant information sources for planning are outlined. On basis of this fundamental aspects the development of protection concepts, including strategies, requirements and boundary conditions are explained.

Finally the preventive measures with focus on constructional aspects like hydraulic and biological engineering, the management of alpine protective forest and measures for avalanches control as well as aspects of regional planning are presented and discussed.

## Part 2: "Process analysis, Modelling and Mitigation of Alpine Hazards"

The lecture will introduce process understanding of gravitational, nival, glacial and periglacial Alpine Hazards in dynamically changing mountain environments. This includes physical and mechanical aspects of process understanding and stochastic descriptions of magnitude and frequency patterns. On basis of this profound understanding, we will introduce benchmark approaches of how to model and anticipate selected gravitational, nival, glacial and periglacial Alpine Hazards.

These approaches will be evaluated with respect to the presently observed and anticipated Environmental Change in Alpine regions. This will be integrated into the development of sustainable adaptation and mitigation strategies in dynamic Alpine Environments. Best practice examples from different mountain environments will be assessed in a final step.

### **Intended Learning Outcomes:**

After a successful participation in the module the students are able to:

- understand the fundamental natural processes in alpine watersheds,
- understand the main issues in water and debris flow management
- understand the full range of gravitational, nival, glacial and periglacial Alpine Hazards in dynamically changing mountain environments
- analyse the relevant strategies and tools for protection works against alpine hazards
- apply scientific and practical strategies for process understanding, anticipation and mitigation of Alpine Hazards

### **Teaching and Learning Methods:**

The module consists of a lecture series. The theoretical framework of processes and dynamics of alpine hazards will be presented in the lecture. Practical Examples illustrate strategies and measures for the anticipation and mitigation of hazards. Furthermore, students are encouraged to study scientific literature in order to enrich the discussion of the issues. In class exercises, selected examples are calculated and distinct quantitative tasks are shown.

### **Media:**

Blackboard work and PowerPoint presentation.

**Reading List:**

Script and PowerPoint slides provided from lecturers.

**Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Prozessanalyse, Modellierung und Vorbeugung/Schutzmaßnahmen für Alpine Naturgefahren  
(Vorlesung, 2 SWS)

Krautblatter M, Rimböck A, Scandroglio R

Water Management in Mountain Regions (Vorlesung, 2 SWS)

Rimböck A ( Fuchs Y ), Fuchs Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV600001: Risk Analysis | Risikoanalyse [RA1]

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a Klausur (duration 90 min).

With the exam the students prove that they are able to reflect and reproduce the contents of the modul. Also the Students demonstrate that they are able to describe and reflect important theories. Throughout the semester, students are given tasks based on the lectures, as well as homework and exercises to continuously check their level of knowledge.

All study materials, literature and simple scientific calculators are permitted as aids in the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The module will assume a basic knowledge of probability concepts such as random variables and their description (e.g., through completion of the BSc course "Zuverlässigkeit und Lastannahmen") [Modulnummer BV600003]. Basic Matlab knowledge is an advantage but not required (an introduction will be given).

#### Content:

1. Introduction, Data analysis using Matlab
2. Probability theory
3. Random variables
4. Parameter estimation
5. Probabilistic modeling of systems
6. Discrete probability models in engineering
7. Continuous probability models in engineering
8. Multivariate probability models



9. Functions of random variables
10. Monte Carlo simulation
11. Extreme value distributions
12. Random processes
13. Outlook

### **Intended Learning Outcomes:**

After participation in the module students are able to understand concepts of uncertainty and information. Students gain a profound toolbox for analyzing engineering problems subject to uncertainty and randomness. At the end of the module, students are able to:

- Know when to apply probabilistic methods and risk analysis
- Use the appropriate probabilistic model for individual and groups of variables
- interpret data analysis (statistics) using Matlab
- Apply Bayes rule for information updating
- Analyze the reliability of systems with statistically dependent elements
- use functions of random variables
- create stochastic process models
- Interpret the quality of a probabilistic analysis

### **Teaching and Learning Methods:**

The module consist of weekly lectures with integrated exercises from the fields of civil, environmental, structural, and mechanical and transportation engineering.

Lectures will be given on the blackboard, including selected illustrations. Case studies should help the understanding of the problems. The lecture notes in PDF form will be distributed at the beginning of the semester.

Simple examples for hand-calculation will be provided within the lectures and more realistic examples will be carried out using Matlab in the computer facilities of the department.

Short tests (15min) will be carried out during the semester, which serve to self-assess the learning success of students.

### **Media:**

- Lectures with blackboard supported by PowerPoint
- Exercises, partly using Matlab (which is available to all TUM students)
- Lecture notes including theory and examples
- Short tests
- 2 homework examples

### **Reading List:**

Lecture notes will be distributed. The following books provide useful supplemental material:

- Kottegod, N. T., and R. Rosso (2008), Applied statistics for civil and environmental engineers, Blackwell, Oxford.
- Ang, A. H.-S., and Tang, W. H. (2006). Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering, Wiley, New York.

- Benjamin, J. R., and C.A., C. (1970). Probability, Statistics and Decision for Civil Engineers, McGraw-Hill, New York.
- Bedford, T., and Cooke, R. (2001). Probabilistic risk analysis: foundations and methods, Cambridge University Press.

**Responsible for Module:**

Herr Prof. Dr. sc. Tech. Daniel Straub [straub@tum.de](mailto:straub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Risikoanalyse (Vorlesung mit integrierten Übungen, 4 SWS)

Straub D [L], Straub D, Bismut E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Elective Modules | Wahlmodule

### Module Description

#### BGU54009: Flood Risk and Flood Management | Hochwasserrisiko und Hochwassermanagement [FRM]

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a 120-minute written test. Only permitted aid is non-programmable calculator. The necessary mathematical formulas are given on the test sheets.

In the written exam, the students demonstrate that they can explain the concepts of hydrological floodwater modeling and flood risk management, taking into account the legal framework as well as social boundary conditions. Through practical tasks on typical flood events, they demonstrate that they can apply quantitative methods for damage and risk assessment, as well as perform risk-based assessment and sensitivity analysis of the effectiveness of flood protection measures.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamentals of hydrology (e.g. Hydrology Basic Module (BGU54006), bachelor program Umweltingenieurwesen, TUM),  
Fundamentals of probability theory and risk analysis (e.g. Environmental Monitoring and Risk Management (BGU54007 or BGU54025), bachelor program Umweltingenieurwesen, TUM),  
Fundamentals of programming in Matlab

#### Content:

First the general motivation of flood risk management (FRM), the social and political framework of FRM as well as tools and models for the hydrologic/hydraulic modelling of the flood events are provided. Also different strategies and measures of technical and decentral flood protection are included. In the second part of the course, quantitative methods for analyzing the flood damage

and flood risk and for risk-based evaluation/optimization of the flood protection measures. The accompanying exercises will provide brief summary of programming in MATLAB and the students will learn how to implement the theory explained in the lectures on simple but realistic examples using Matlab and the water balance model LARSIM, which is used wide spread in Middle Europe for flood forecasts.

#### Lecture

- Safety, security, and risk
- The risk management cycle
- Qualitative and quantitative methods for flood risk assessment
- Planning of flood protection measures: determination of design values
- Flood frequency statistic base on gauged data
- Contents and significance of the EU directive on the assessment and management of flood risks
- Overview of technical and decentral flood protection measures
- Failure of flood protection measures
- Flood hazard scenarios
- Risk and risk acceptance: Communication of risks and legal aspects.

#### Exercise

- LARSIM: Understanding and dealing with the water balance model LARSIM in reasons of flood forecast and river basin modelling.

#### Quantitative risk assessment: lecture and exercise

- Decision-making, risk acceptance, optimization of mitigation measures
- Flood damage assessment
- Risk quantification
- Uncertainty quantification, sensitivity analysis
- Issues of long-term planning: non-stationarity, adaptability

#### **Intended Learning Outcomes:**

After completing the module, the students are able to:

- Understand the basic concepts of flood risk management as well as its legal and social framework,
- to apply methods for the hydrological modeling of flood events;
- to apply quantitative methods for general risk assessment and damage assessment as well as for specific flood risks
- evaluate and select the effectiveness of flood protection measures.
- to apply sensitivity analysis
- to use the MATLAB programming in the specific field of flood risk management.
- to use the hydrological water balance model LARSIM to solve questions of flood prediction.
- to structure and implement the theoretical and mathematical concepts in calculation algorithms.

#### **Teaching and Learning Methods:**

The module consists of lectures with integrated exercises.

The theoretical basics are presented through a lecture series. The students are encouraged to study the recommended literature and deepen their knowledge in certain topics. Computer exercises based on practical problems are solved by the students. They sharpen their technical skills in dealing with MATLAB and LARSIM. The exercises are individual or group work. Voluntary homework tasks, which are to be worked in groups,

**Media:**

Power-Point-Presentation,  
Blackboard,  
Computer lab

**Reading List:**

The documents and resources listed below are some examples for your interest:

Flood Manager E-Learning (TU Hamburg-Harburg): <http://daad.wb.tu-harburg.de/homepage/>

Merz, B., J. Hall, M. Disse, and A. Schumann. "Fluvial Flood Risk Management in a Changing World." *Natural Hazards and Earth System Science* 10, no. 3 (March 16, 2010): 509–527.

doi:10.5194/nhess-10-509-2010.

Rogger, M., Kohl, B., Pirkl, H., Viglione, A., Komma, J., Kimbauer, R., Merz, R., Blöschl, G., 2012. Runoff models and flood frequency statistics for design flood estimation in Austria – Do they tell a consistent story? *J. Hydrol.* 456–457, 30–43.^

Bründl, M., Romang, H.E., Bischof, N., Rheinberger, C.M., 2009. The risk concept and its application in natural hazard risk management in Switzerland. *Nat. Hazards Earth Syst. Sci.* 9, 801–813.

Pianosi, F., Wagener, T., Rougier, J., Freer, J., Hall, J., 2014. Sensitivity Analysis of Environmental Models: A Systematic Review with Practical Workflow, in: *Vulnerability, Uncertainty, and Risk*. American Society of Civil Engineers, pp. 290–299.

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse ([markus.disse@tum.de](mailto:markus.disse@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Flood Risk and Flood Management (Vorlesung mit integrierten Übungen, 4 SWS)

Disse M [L], Broich K, Disse M ( Broich K, Gerner A ), Gerner A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU54016: Process Based Modelling of Mesoscale Pre-alpine Catchments | Prozessbasierte Modellierung mesoskaliger voralpiner Einzugsgebiete [MPAC]**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The exam consists of a project work to be presented both in written and oral form. The written report (30-40 pages long) is a group work on the theoretical background and the application of the two presented models including preprocessing, model generation and results. The results have to be presented to the class in an oral presentation (20 minutes presentation followed by a discussion). The written report and the oral presentation are equally weighted.

Auxiliary means are not allowed.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Basic knowledge in hydrology and hydraulics

#### **Content:**

- 1) Dominant hydrological processes in pre-alpine catchments: Precipitation types and snow processes; runoff generation, concentration and flood routing
- 2) Data in small alpine catchments: availability, quality, acquisition and analysis
- 3) Types of hydrological and hydraulic models and applicability in pre-alpine catchments
- 4) Generation, parameterization and calibration of the process based hydrological model WaSiM
- 5) Model sensitivity analyses with focus on interpolation of the meteorological input, snow processes and runoff concentration
- 6) Process based modeling of the flood routing processes using the 2D-hydrodynamic-numerical model HYDRO\_AS-2D
- 7) Analysis of the water balance influenced by different land use and climatic boundaries

8) Quantification of the effectiveness of flood mitigation measures using the (coupled) modeling approach

**Intended Learning Outcomes:**

At the end of the module, students are able to understand the main processes in pre-alpine catchments like snow processes as well as runoff generation, runoff concentration and flood routing processes. Additionally, they are able to understand different methods for the calculation of these processes. Moreover, students are able to use a physically based hydrological model and a 2d hydrodynamic-numerical model to simulate the rainfall runoff process in pre-alpine catchments and its influencing parameters caused by the special circumstances of these regions in a widely realistic and transparent way. The students are able to generate event based scenarios as well as land use scenarios and based on this to evaluate different flood mitigation strategies for such regions.

**Teaching and Learning Methods:**

Lectures, block seminar and exercises

**Media:**

- PowerPoint presentations
- Technical manuals

**Reading List:**

DeWalle, D.R. & Rango, A. (2008): Principles of snow hydrology. Cambridge University Press, Cambridge and UK and New York.

Hydrotec Ingenieurgesellschaft mbH & M. Nujić (2014): Benutzerhandbuch HYDRO\_AS-2D - 2D-Strömungsmodell für die wasserwirtschaftliche Praxis. Aachen, November 2014

Schmocker-Fackel, P., Naef, F. & Scherrer, S. (2007). Identifying runoff processes on the plot and catchment scale, Hydrol. Earth Syst. Sci., 11, 891 - 906. [www.hydrol-earth-syst-sci.net/11/891/2007/](http://www.hydrol-earth-syst-sci.net/11/891/2007/).

Schulla, J. (2014): Model Description WaSiM: Water balance Simulation Model. Zürich.

Warscher, M., Strasser, U., Kraller, G., Marke, T., Franz, H. & Kunstmann, H. (2013): Performance of complex snow cover descriptions in a distributed hydrological model system: A case study for the high Alpine terrain of the Berchtesgaden Alps. In: Water resources research 49 (5), pp. 2619-2637.

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse

**Courses (Type of course, Weekly hours per semester), Instructor:**

Process based modelling of mesoscale pre-alpine catchments (Vorlesung, 4 SWS)

Disse M [L], Broich K, Disse M, Merk F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU54026: Urban Flood Modelling | Modellierung städtischer Überschwemmungen [UFM]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

At the end of the module, students submit a report (10-15 pages) with corresponding presentation (circa 15 min). The report is a written record and summary of the three main exercises followed during the Module, covering the setup, application and analysis of the results from three different urban flood models (sewer network model, overland flow model and dual drainage flow model). The report will verify that the students understood the basic concepts of flood modelling in urban areas and that they were able to apply those concepts for the solution of problems within a given period of time. The students will work in groups of maximum of three. The presentation is also done in groups. The presentation will verify if the students are able to present their results in a coherent manner, discuss and answer questions related to urban flood modelling.

Prüfungsart

Report (10-15 pages)

Prüfungsdauer (in Minuten)

15 min presentation +10 min discussion

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Fundamentals of Hydrology (e.g. Hydrologie Grundmodul)
- Basic Knowledge of Sewer Drainage Systems (e.g. Siedlungswasserwirtschaft Grundmodul - Kanalisation)
- Basic Knowledge of Arc-Map

#### Content:

Introduction: Overview of the most important urban hydrological and hydraulic processes and concepts.

Challenges in urban flood modelling, in relation to flood management and flood risk assessment.

T1. Sewer drainage model I - SWMM model setup of Maxvorstadt (computational work).

T2. Sewer drainage model II - analysis of results (computational work).

Introduction to overland flood models in urban areas.

T3. Overland flow model I – P-DWave model setup of Maxvorstadt (computational work).

T4. Overland flow model II – analysis of results (computational work).

Introduction to dual drainage models.

T5. Dual drainage flow model I - P-DWave/SWMM setup of Maxvorstadt (computational work).

T6. Dual drainage flow model II - analysis of results (computational work).

Urban flood management: Sustainable Urban Drainage System (in Munich).

Discussion/Feedback on the report.

Presentation and discussion of the report.

Wrap-up.

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### **Intended Learning Outcomes:**

The students at the end of the module will be able to understand and analyse:

- the fundamental concepts of urban flood modelling,
- the need and usefulness of different model types
- the different types of Sustainable Urban Drainage Systems (SUDS)

Finally, the students are able to discuss the range of applicability as well as advantages and disadvantages of different UFM for different contexts, namely, flood risk and flood management, and for different densifications of urban areas

### **Teaching and Learning Methods:**

Lecture with integrated computational exercises. 3 computer exercises (each split in two parts).

The exercises can be done in group. Students submit a report (10–15 pages) summarizing their results. Students will receive feedback during the lectures on their reports. Students will prepare and present their reports during the lecture period

### **Media:**

Powerpoint, black-board, PDFs, teamwork followed by discussion

### **Reading List:**

### **Responsible for Module:**

Jorge Leandro, [jorge.leandro@tum.de](mailto:jorge.leandro@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Urban Flood Modelling (Vorlesung mit integrierten Übungen, 2 SWS)

Teixeira Leandro J [L], Teixeira Leandro J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU60017: Probabilistic Life Cycle Analysis and Integrity Management of Infrastructures | Probabilistische Lebenszyklusanalyse und Unterhaltsmanagement von Infrastrukturbauten

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam is a take-home exam

#### Repeat Examination:

#### (Recommended) Prerequisites:

The course will assume a basic knowledge of probability concepts such as random variables and their description (e.g., through completion of the MSc course “Risk Analysis” or “Stochastic Finite Element Methods”). Basic knowledge of Matlab or Python is required for the exercises.

#### Content:

After a short introduction in probability theory, different approaches to monitor a structure are introduced:

1. General introduction
2. Basics of reliability analysis
3. Reliability of maintained systems
4. Time value of money
5. Decision theory and cost-benefit analysis
6. Models of deterioration mechanisms
7. Repair and rehabilitation
8. Inspection and monitoring strategies
9. Life-cycle cost analysis (LCCA)

## 10. Optimization of inspection and monitoring strategies

### **Intended Learning Outcomes:**

This course enables the student to understand, analyze and communicate the elements of life-cycle reliability and asset integrity management subject to uncertainty and randomness. Upon completion of the module, students will be able to:

- Understand the fundamental concepts and challenges in infrastructure asset integrity management
- Understand and evaluate life-time reliability, availability and risk
- Perform probabilistic evaluations of the life-time performance of aging infrastructures by Monte Carlo simulation
- Assess the reliability of maintained structures
- Perform cost-benefit-analyses of asset integrity management strategies
- Understand the time-value of money and its relevance in infrastructure management
- Understand probabilistic models of inspection and monitoring
- Understand the effect of repair and rehabilitation
- Perform a life-cycle cost analysis
- Optimize inspection strategies and monitoring
- Implement analysis methods in computational tools such as Python or Matlab

### **Teaching and Learning Methods:**

The course is a 1-week (5 days) block course. It consists of lectures (50%) and exercises (50%), which implement the theory to 1-2 example structures and infrastructures.

Lectures will be given partly on the black/whiteboard and partly by presentations on slides. The whiteboard allows to develop key concepts and mathematical formulations at a pace that is conducive to a deeper understanding. The presentations on slides facilitates presentation of how these concepts apply to real systems and present case-studies.

In the exercise part, the students will be asked to solve selected exercises that are drawn from one or two case studies. These case studies will be introduced at the beginning of the course and utilized throughout. Some of the exercises will require the use of suitable software tools, such as Matlab or Python. Students will be required to develop and present the solution of selected exercises in class.

### **Media:**

- Lectures with blackboard supported by slides
- Exercise sheets
- Matlab code examples

### **Reading List:**

References and selected materials will be provided

### **Responsible for Module:**

Max Teichgräber

**Courses (Type of course, Weekly hours per semester), Instructor:**

Probabilistic life cycle analysis and integrity management of infrastructures (Vorlesung mit integrierten Übungen, 3 SWS)

Bismut E, Straub D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU60018: Estimation of Rare Events and Failure Probabilities | Abschätzung von seltenen Ereignissen und Versagenswahrscheinlichkeiten

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The course assessment takes place as a project work. The students will solve a practical problem that requires implementation of the methods discussed in class in a computer code. The students will be evaluated based on a written project report that documents the implemented approach and obtained results. The students will present their project in a 15-minute presentation followed by a discussion of the presented solution approach. The aim of the project is that students become familiar with the concepts discussed in class through hands-on experience. The project report will assess the students' understanding of the implemented methods and their applicability to specific problems. The purpose of the presentation is to assess the students' ability to describe theoretical concepts and communicate the adopted approach to solve a practical problem in a clear fashion.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Risk Analysis/Stochastic Finite Element Methods

The course will assume a basic knowledge of probability concepts such as random variables and their

description (e.g., through completion of the MSc course “Risk Analysis” or “Stochastic Finite Element Methods”). Basic knowledge of Matlab or Python is required for the exercises.

**Content:**

The course introduces shortly probability theory. Then all state of the art methods to calculate the probability of rare events are introduced.

1. General introduction
2. Random variables/Random vectors
3. Rare events and reliability problems
4. Approximate reliability analysis
5. Simulation of random variables
  - 5(a). Pseudo-random sampling
  - 5(b). Rejection sampling
  - 5(c). Markov chain Monte Carlo methods
6. Simulation of rare events
  - 6(a). Monte Carlo simulation
  - 6(b). Importance sampling
  - 6(c). Cross-entropy method
7. Simulation in high dimensions
  - 7(a). Screening method
  - 7(b). Subset simulation
8. Bayesian analysis of rare events

**Intended Learning Outcomes:**

This course enables the students to understand and implement state-of-the-art methods for estimating

probabilities of rare events. In the end of the semester the students will be able to:

- Generate random samples from arbitrary distributions
- Apply approximations to rare events and reliability problems
- Estimate efficiently rare event probabilities with sampling methods
- Estimate rare event probabilities in problems with large number of random variables
  
- Update rare event probabilities with observations
- Implement advanced simulation methods in computational tools such as Python or Matlab

**Teaching and Learning Methods:**

The course consists of weekly lectures. Lectures will be given partly on the black/whiteboard and partly by presentations on slides. The whiteboard allows to derive theoretical concepts and mathematical formulations at a pace that is conducive to a deeper understanding. The presentations

on slides facilitates graphical illustration of the new concepts and enables to make complex content more comprehensible.

Homework exercises will be given and their solutions will be posted in moodle. A selection of the homework exercises will be discussed in class. Some of the exercises will require the use of suitable software tools, such as Matlab or Python. Homework exercises facilitate understanding of the taught methods and their applicability to different problems.

**Media:**

- Lectures with blackboard supported by slides
- Exercise sheets
- Matlab code examples

**Reading List:**

References and selected materials will be provided

**Responsible for Module:**

Max Teichgräber

**Courses (Type of course, Weekly hours per semester), Instructor:**

Estimation of rare events and failure probabilities (Vorlesung mit integrierten Übungen, 3 SWS)

Ehre M, Papaioannou I

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU60019: Stochastic Finite Element Methods | Stochastische Finite Elemente Methode [SFEM]

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

A take-home exercise sheet and will be given after the first half of the course. The purpose of the exercise sheet is to assess the students understanding of the basic concepts of probability theory discussed in the first part of the course. The content will be closely related to the exercises and theoretical concepts discussed in class. The final exam will be oral. The students will be asked to solve simple exercises that reflect the practical topics discussed in the lecture. The purpose is to assess the ability of the students to understand the basic principles of stochastic finite element methods and to apply these methods for analyzing the impact of uncertainties on physical systems. The students will be given 30min to prepare for the exam; the exam duration will be 25min. The final grade will be based on the final exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The course will assume basic knowledge of the linear finite element method for the solution of one-dimensional linear elasticity problems.

Basic knowledge of probability theory is recommended, but not required. Basic knowledge of Matlab is an advantage.

#### Content:

This lecture is an introduction to the basic concepts of stochastic finite element methods for the uncertainty quantification of elastostatic systems. The course covers the following contents:

1. Introduction to probability theory and stochastic calculus
- 1(a). Random variables

- 1(b). Random vectors
- 2. Functions of random variables
  - 2(a). Estimation of moments of functions
  - 2(b). Probabilistic transformation
  - 2(c). The Monte Carlo method
- 3. Random fields
  - 3(a). Discretization of random fields
  - 3(b). Reduction of stochastic dimension by spectral decomposition
  - 3(c). The Karhunen-Loève expansion
- 4. Finite elements with random inputs
  - 4(a). The linear elastostatic problem and its solution by the finite element method
  - 4(b). Stochastic stiffness matrix and force vector
  - 4(c). Monte Carlo method, Perturbation method
- 5. Advanced Monte Carlo methods
  - 5(a). Advanced sampling methods
  - 5(b). Multi-level Monte Carlo method
- 6. Spectral stochastic finite elements
  - 6(a). Polynomial chaos expansion
  - 6(b). Stochastic Galerkin method
  - 6(c). Stochastic collocation methods

#### **Intended Learning Outcomes:**

This course enables the students to understand and implement numerical methods for analyzing physical systems with uncertain input parameters. In the end of the semester the students will be able to:

- Understand the basic concepts of probability theory
- Define random vectors and random fields based on their second moment properties
- Discretize random fields into a finite number of random variables
- Assess the applicability of different stochastic discretization methods based on specific problem settings
- Apply Monte Carlo methods for solving uncertain finite element systems
- Apply spectral stochastic finite element methods with various algorithmic settings

#### **Teaching and Learning Methods:**

The course consists of weekly lectures. Lectures will be given partly on the black/whiteboard and partly by presentations on slides. The whiteboard allows to derive theoretical concepts and mathematical formulations at a pace that is conducive to a deeper understanding. The presentations on slides facilitates graphical illustration of the new concepts and enables to make complex content more comprehensible.

Homework exercises will be given and their solutions will be posted in moodle. A selection of the homework exercises will be discussed in class. Some of the exercises will require the use of suitable software tools, such as Matlab or Python. Homework exercises facilitate understanding of the taught methods and their applicability to different problems.

**Media:**

- Lectures with blackboard supported by slides
- Exercise sheets
- Matlab code examples

**Reading List:**

A script will be distributed in electronic form. For further reading, the following are recommended:

- Kleiber, M, Hien, TD. The stochastic finite element method. Basic perturbation and computer implementation. New York: Wiley; 1992
- Ghanem, RG, Spanos, PD. Stochastic finite elements: A spectral approach. New York: Springer; 1991 (reissued by Dover Publications; 2004)
- Sudret, B, Der Kiureghian, A. Stochastic finite elements and reliability: A state-of-the-art report. University of California, Berkeley, Technical Report no UCB/SEMM-2000/08; 2000
- Xiu, D. Numerical methods for stochastic computations: A spectral method approach. Princeton: Princeton University Press; 2010
- Cliffe, KA, Giles, MB, Scheichl, R, Teckentrup, AL. Multilevel Monte Carlo methods and applications to elliptic PDEs with random coefficients. Comput Visual Sci (2011) 14:3-15

**Responsible for Module:**

Dr. Iason Papaioannou [iason.papaioannou@tum.de](mailto:iason.papaioannou@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Stochastic Finite Element Methods (Vorlesung, 4 SWS)

Papaioannou I [L], Chan J, Papaioannou I

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU60021: Risk Assessment and Reliability of Engineering Systems | Risikobewertung und Systemzuverlässigkeit [RA&SR]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

There will be a oral exam of 40 minutes duration at the end of the semester. It will be an open book exam, thus notes and aids are allowed. The student should study the problem and outline a solution during the first 20 minutes. In the subsequent 20 minutes he/she will present his/her solution and answer follow-up questions. Solutions will be discussed and examined during iterative rounds of questions. The oral examination enables the examiners to be responsive to the individual student and to evaluate the student's competences realistically.

The problems to be solved in the exam are based on the lecture contents and the exercises of the semester. The students need to be able 1) to explain main concepts in their own words and 2) to solve arithmetical problems. The students are supposed to show if and up to what extent they have understood the principles and concepts of the theory of probability and if they are able to apply these concepts to problems in the field of engineering.

The student can submit an assignment during the semester. Successful completion gives a bonus of 0.3 for the final grade.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Risk Analysis

#### Content:

Part Risk Assessment:

1. General introduction
2. Bayesian networks

3. Utility theory
4. Decision analysis
5. Life-cycle analysis and cost-benefit analysis
6. Risk acceptance
7. Risk management

**Part System Reliability:**

1. General introduction
2. Time-dependent reliability
3. Binary system models
4. Fault tree and event tree analysis
5. Dependent failures
6. Physically-based system models
7. Sampling-based system reliability
8. Performance and sensitivity measures

**Intended Learning Outcomes:**

This course enables the student to analyze, manage and communicate the reliability of and risks in civil systems and environment. Upon completion of the module, students will be able to:

- Understand reliability, risk, utility, and, decisions.
- Understand traditional tools for system reliability and risk analysis, such as fault, event and decision trees.
- Select appropriate system models for reliability assessment.
- Model complex engineering systems and decisions under uncertainty
- Identify important components and failure modes in systems.
- Assess risk acceptance criteria.
- Plan risk management for engineering systems.
- Model complex engineering systems through sampling and simulation based methods.
- Implement the methods in computational tools such as Matlab

**Teaching and Learning Methods:**

The course consists of lectures, including application examples, and exercises from the fields of civil, environmental, structural, mechanical and transportation engineering.

Lectures will be given on the black/whiteboard, including selected illustrations. Case studies should help the understanding of the problems. The lecture notes in PDF form will be distributed at the beginning of the semester.

Homework, accompanying the lectures, will be provided.

**Media:**

- Lectures with blackboard supported by slides
- Lecture notes including theory and examples
- Optional homework examples

**Reading List:**

Lecture notes and selected papers will be distributed.

**Responsible for Module:**

Herr Prof. Dr. sc. Tech. Daniel Straub [straub@tum.de](mailto:straub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Zuverlässigkeit von Systemen (Vorlesung, 2 SWS)

Straub D, Teichgräber P

Risikobewertung (Vorlesung, 3 SWS)

Straub D, Teichgräber P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66041: Contaminant Transport and Remediation | Transport und Sanierung von Schadstoffen [ContTransRemed]

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

At the end of the module, students participate in a written exam of 120 minutes duration. The exam will focus on the physical and chemical processes underlying contaminant transport and environmental remediation strategies and on the development of related computer models. The exam will verify that the students understand the principles to plan and carry out remediation of contaminated soils and water bodies. Furthermore, it will verify that the students understand basic concepts of environmental chemistry and pollutant transport in the environment and that the students are able to apply those concepts for the solution of problems within a given period of time. The exam will consist of open questions, multiple choice questions and exercises which will require short computations. In knowledge and transfer questions, the students demonstrate both their theoretical knowledge in pollutant hydrogeology and their ability to interpret and evaluate scientific measurement results quantitatively, to develop a prediction for mass dispersion in given exemplary scenarios and to clearly present and visualise the results, e.g. in schematic sketches and cross sections. No auxiliary material is allowed during the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in hydrology, hydrogeology and environmental chemistry (e.g., the MSc module Case studies in technical hydrogeology)

#### Content:

Students acquire the necessary knowledge and skills to quantitatively describe and evaluate the transport of pollutants in groundwater.

- Legal bases for the quality of groundwater and surface water

- Transport of water constituents in saturated and unsaturated environments (dispersion, sorption, degradation)
- Multiphase flow,
- Reactive mixing in surface water bodies
- Colloid transport,
- Transport properties of inorganic and organic contaminants
- General introduction on fate and transport of contaminants in the environment
- Analytical and numerical modeling of reactive solute transport
- Principles of in situ chemical oxidation
- Remediation technology for the unsaturated zone
- Land management

### **Intended Learning Outcomes:**

After participating in the module, the students are able to

- to quantify the spread of pollutants in groundwater and assess the risk of groundwater contaminations in a pollutant-specific way.
- to understand the effects of technical measures (e.g. iron removal, hardening, chlorination) in water treatment on the behaviour of pollutants and to transfer this knowledge to other issues (e.g. mixing of near-surface groundwater with deep groundwater)
- to understand the basic processes controlling commonly applied environmental remediation strategies
- to predict the effectiveness of different remediation strategies

The main objective of the moodle based modeling exercises is to enable students to understand, apply and further develop models to plan, predict and carry on remediation actions.

### **Teaching and Learning Methods:**

The module consists of two lectures. The teaching philosophy behind this module is based on the evidence that different study goals will be achieved using different approaches. The theoretical lectures' contents are presented by the lecturer using both the blackboard and digital slides. The students will get familiar with the subject solving independently relevant practical problems. Additionally, modelling exercises are offered on Moodle (asynchronous), with which the students train their programming skills

### **Media:**

Presentations (beamer/blackboard) , case studies in teams, exercise on e-learning platform

### **Reading List:**

- Kitanidis, P. K. and McCarty, P.L. (2012), Delivery and mixing in the subsurface: Processes and Design Principles for in situ remediation
- Siegrist et al. (2011), In Situ chemical oxidation for groundwater remediation
- Schoor J.L. (1996), Environmental Modeling fate and transport of pollutants in water, air and soil
- Appelo C.A.J, Postma, D. (2006) Geochemistry, Groundwater and Pollution, Balkema, Leiden.
- Clark & Fritz (1997): Environmental Isotopes in Hydrogeology.-398 S. Lewis Publisher.
- Domenico, Schwartz(1998): Physical and chemical hydrogeology.- (Wiley).



Fetter (2001): Applied Hydrogeology.- New Jersey (Prentice-Hall).

Fetter, Boving, Kreamer (1998): Contaminant Hydrogeology, Long Grove (Waveland Press)

Matthess, G. (1994): Die Beschaffenheit des Grundwassers.- 499 S.; Berlin

**Responsible for Module:**

Prof. Dr. Thomas Baumann

**Courses (Type of course, Weekly hours per semester), Instructor:**

Transport von Schadstoffen im Grundwasser (Vorlesung, 2 SWS)

Baumann T

Environmental Remediation Strategies (Vorlesung, 2 SWS)

Chiogna G [L], Chiogna G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU67001: Landslides | Hangbewegungen

Version of module description: Gültig ab summerterm 2013

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

credit requirement: unsplit examination with pocket calculator and formulary; pass/fail credit requirement: 3 days mandatory field trips (3 x 8 h), protocol, not graded.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

As-built surveys and geodetical monitoring, fundamentals of geology

#### Content:

- Definition, terms & classification
- Landslide types and processes
- Landslide causes and triggers
- Case studies Goldau, Rufi, Grätli, Vajont, Elm
- Investigation and analysis of landslides
- Mapping of phenomena, Hazard & risk maps
- Monitoring techniques, early warning systems
- Case study Sudelfeld, research project alpEWAS
- Remote sensing reconnaissance
- Principles of risk assessment for natural hazards
- Assessing the probability of landslide hazards
- Vulnerability and exposure to landslide hazards
- Cost-benefit optimization of mitigation measures
- Landslide risk communication and management

- Mitigation measures
- Geodetical monitoring
- Concepts, instrumentation, processing
- European case studies (alpine landslides)
- North American case studies (coastal landslides)
- Case studies from developing and emerging countries

### **Intended Learning Outcomes:**

After the course, students are familiar with different types of landslides and are able to classify and describe landslides types and processes on an international approved level. Students will be able to differentiate causes and triggers of a landslide and to analyse different movement and transportation types. They will be able to select the appropriate investigation techniques for monitoring and to apply hazard mapping and zoning techniques. The students will know and understand the principles of risk assessment and management for landslides and other gravitational natural hazards. They will be able to conduct and interpret basic risk analyses and cost-benefit optimization of landslide mitigation measures.

### **Teaching and Learning Methods:**

The course will consist of 3 lectures. The lectures include videos, slide shows and demonstrations of processes. There will be mandatory exercises and optional field days showing various landslide case studies which have been discussed during the lectures.

### **Media:**

Powerpoint presentation, viewgraphs, blackboard, videos, lecture notes, field trip

### **Reading List:**

- TURNER and SCHUSTER: Landslides: Investigation and Mitigation, National Academy Press, 1996
- CENAT: Dealing with natural hazards and risks, module 3 landslides, web-based lectures, Kompetenzzentrum Naturgefahren der Schweiz CENAT, ETH Zürich
- DUNNICLIFF: Geotechnical instrumentation for monitoring field performance, Wiley, 1993
- SCHOFIELD & BREACH: Engineering Surveying, sixth edition, Elsevier, 2007

- BONNARD, FORLATI & SCAVIA: Identification and Mitigation of Large Landslide Risks in Europe
- Advances in Risk Assessment, European Commission Fifth Framework Programme, IMIRILAND Project, Balkema Publishers, 2004

- ClimChAlp (CLIMATE CHANGE, IMPACTS AND ADAPTATION STRATEGIES IN THE ALPINE SPACE): Slope Monitoring Methods - State of the Art Report, 2008 [http://www.geo.bv.tum.de/images/stories/dokumente/climchalp\\_-\\_work\\_package\\_6\\_report.pdf](http://www.geo.bv.tum.de/images/stories/dokumente/climchalp_-_work_package_6_report.pdf)

**Responsible for Module:**

Kuroschi Thuro (thuro@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geodetic Monitoring of Landslides (Vorlesung, 1 SWS)

Holst C, Raffl L

Landslides - Recognition, Investigation & Mitigation Measures (Vorlesung, 2 SWS)

Krautblatter M, Holst C, Straub D, Kiefer C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV170004: River Engineering and Hydromorphology | Flussbau und Hydromorphologie [BUI River]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In a written (closed book) examination, students will prove that they are able to understand and reproduce the basic concepts of river engineering and the hydromorphology in a short time, and can propose solutions to application problems.

Due to the current situation (Covid19), the exam will additionally be offered as an exam via videoconference (moodle+zoom).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basic knowledge in Hydraulic Engineering and Water Resources Engineering

#### Content:

- Alluvial channel flow and sediment transport
- Numerical hydromorphological modeling
- River morphology, river response and river stabilization
- Application of HEC-RAS for 1D flow, sediment transport and morphology change

#### Intended Learning Outcomes:

Students will be able to

- understand the complex problems in sediment transport in rivers;
- understand the link between morphologic change and sediment transport; Interaction possibilities through river engineering techniques;
- apply numerical model as an alternative tool in river works development.

**Teaching and Learning Methods:**

The module consists of a lecture and an exercise course. The theoretical framework will be presented in the lecture and illustrated with examples; real and virtual models will be presented and explained in discussions with the students. Furthermore, students are encouraged to study scientific literature in order to enrich the discussion of the issues. In the exercises, selected examples are presented and distinct practical questions are shown. In addition to lectures and exercise sheets and E - tests are part of the module, where the practical application is deepened.

**Media:**

Blackboard explanation and PowerPoint presentation

**Reading List:****Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

River Engineering and Hydromorphology (Vorlesung, 2 SWS)

Bui M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV180004: Modelling of Water Quality in Aquatic Systems | Modellierung der Wassergüte in aquatischen Systemen**

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination is a 60-minute written test. The aim of the written test is to verify that the basic approaches for modeling of aquatic systems were understood. These problems must be analyzed and based on learning outcomes acquired in the course of the module, find and implement solutions in limited time.

The answers require partly own formulations, partly graphical visualization. The focus is on short calculation and modeling tasks. For the exam no aids are permitted except for a non-programmable calculator.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basics of aquatic systems as well as in mathematical, physical and chemical knowledge are required.

#### **Content:**

1. INTRODUCTION. Aquatic systems and their types: natural and man-made aquatic systems; water and wastewater treatment units. Common features of aquatic systems. The concept of mathematical modeling of aquatic systems: the general hydrodynamic and mass balance equations.

2. THEORY OF REACTORS. Reactions kinetics - order of reaction. Reactor vessels. Theoretical types of flow: Plug Flow vs. Continuous Stirred Tank Reactors. Hydraulic retention time and the concept of Flow through Curve. Reactors in series. Reactor analysis.

3. SIMPLE APPROACHES FOR MODELING OF BIOGAS PRODUCTION. Using Excel for implementing simple models. Useful tools. First steps in modeling.

4. AQUASIM. General introduction to the software. Application exercise for a river simple system for nitrification and biomass decay. Calibration of model parameters. Critical discussion of measurements and model outputs.

**Intended Learning Outcomes:**

After completion of the module students can describe the approaches for simple models, set-up and analyze mass and energy balances, are able to create simple simulations with own modifications.

**Teaching and Learning Methods:**

.In the lecture theoretical principles are first taught using both presentations and black board. In following exercises with commercial (Excel) or specialized software (AquaSIM), the students apply the lessons learned on similar tasks and thereby internalize the approach. The results are discussed and analyzed afterwards.

**Media:**

Board, beamer, computer

**Reading List:**

Chapra S. C. (2008) Surface Water-Quality Modeling. Waveland Press Inc, Long Grove.

Maniak, U. (1997) Hydrologie und Wasserwirtschaft - Eine Einführung für Ingenieure. Springer Verlag, Heidelberg.

Reichert, P. (1998) AQUASIM 2.0 – User Manual. Swiss Federal Institute for Environmental Science and Technology (EAWAG), Dübendorf.

Wichern, M. (2010): Mathematische Simulation biochemischer Prozesse in der Siedlungswasserwirtschaft, Oldenbourg Industrieverlag, München.

**Responsible for Module:**

Dr.-Ing. Konrad Koch, k.koch@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modelling of aquatic systems (Modellierung aquatischer Systeme) (Vorlesung, 2 SWS)

Koch K [L], Koch K

Modelling of aquatic systems (Vorlesung, 2 SWS)

Koch K [L], Koch K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV460014: Environmental Hydrodynamic Modelling | Hydrodynamische Modellierung für Umweltingenieure [EHDM]

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Formal assessment is based on two components: homework assignment and project work.

During the course, problem sets will be assigned. Homework solutions are the result of individual effort. However, group discussions of the concepts covered on the homework and review of the course material is encouraged. The students show that they are able to understand

- Basics of analytical and numerical approaches relevant to environmental hydraulic problems.
- Elementary programming concepts using the basic MATLAB architecture and mathematical / numerical routines.

The students are required to complete one class project. The project will be applications of HEC-RAS software to real problems. Similarly to homework assignment, project work and report will also be done individually. We expect a 10-15 page write-up about the project, which should clearly and succinctly describe the project goal, methods, and numerical results. At the end of the course, each student will be given 10 minutes for the oral presentation of their project, with an additional 5 minutes for questions. The project work will be graded on the basis of

- Their understanding of the overall course material, and
- Their ability to work independently with the relevant software applications.

The nominal subject grade is a weighted sum of the assignment grade (40%), the project report grade (30%) and the project presentation grade (30%).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Content:**

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Intended Learning Outcomes:**

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Teaching and Learning Methods:**

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Media:**

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Reading List:**

see course descriptions for

- “Environmental Hydrodynamic Modelling”

**Responsible for Module:**

PD Dr.-Ing. habil. Minh Duc Bui (bui@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Environmental Hydrodynamic Modelling (Vorlesung, 2 SWS)

Bui M

Environmental Hydrodynamic Modelling II (Vorlesung, 2 SWS)

Bui M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV490053: Numeric Analysis 1 - Fundamentals | Numerische Methoden 1 - Grundlagen

Version of module description: Gültig ab winterterm 2021/22

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>52.5 | <b>Contact Hours:</b><br>37.5        |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Eine Bewertung erfolgt durch eine 60-minütige Klausur. Die Studierenden sollen anhand von Wissensfragen zeigen, dass sie in der Lage sind, die wesentlichen mechanischen Grundlagen und Interaktionen von Versagensmechanismen sowie die verschiedenen erlernten Berechnungsverfahren, etwa der Grenzgleichgewichtsanalyse sowie die theoretischen Hintergründe, u.a. der Inversion oder der Diskontinuumsmodellierung, strukturiert und problemlösungsorientiert zu erklären. Anhand konkreter praktischer Fallbeispiele zur Anwendbarkeit von Bruchkriterien, der Gleichgewichtsanalyse und Modellierung sollen sie zeigen, dass sie die mechanischen Grundlagen, wie etwa das Schmidt'sches Netz, in einem numerischen Modell anwenden können und selbst händische Analysen durchführen können. Erlaubte Hilfsmittel sind ein PC, ein Taschenrechner und eine Formelsammlung. Die Klausur eignet sich hier am besten weil auch synoptische Zusammenhänge aus mehreren Gebieten analysiert, bewertet und eigene Lösungsideen entwickelt werden sollen. Mithilfe des PCs können kurze, praktische Modellierungsaufgaben gelöst werden.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Grundkenntnisse in der Klassifikation und Erkennung von Hangbewegungen. Es werden gute PC Kenntnisse und ein Interesse an verschiedenen numerischen Modellierssoftwares erwartet.

#### Content:

T

### **Intended Learning Outcomes:**

Die Studierenden sind am Ende des Moduls in der Lage...

- ... zu verstehen, was die mechanischen Grundlagen und Interaktionen von Versagensmechanismen sind
- ... zu verstehen, wie sie mit dem Schmidt'schen Netz selbst händische Analysen durchführen können
- ... potentielle Blockmobilisierungen im Tunnelbau zu analysieren
- ... das Zusammenspiel und den Einfluss der verschiedenen Materialparameter auf die Gebirgsfestigkeit und die verschiedenen Bruchkriterien zu verstehen
- ... verschiedene Berechnungsverfahren der Grenzgleichgewichtsanalyse zu verstehen
- ... selbst das Lamellenverfahren anzuwenden und die Ergebnisse zu bewerten
- ... die Grundlagen der Finite Elemente Analyse zu verstehen
- ... selbst Spannungsverhältnisse in einem tiefliegenden Tunnel zu analysieren
- ... den theoretischen Hintergrund der Inversion von geoelektrischen Daten zu verstehen
- ... die aus der Inversion von geoelektrischen Daten gewonnen Ergebnisse zu analysieren und zu bewerten
- ... den theoretischen Hintergrund der Diskontinuumsmodellierung zu verstehen
- ... die Unterschiede sowie die Vor- und Nachteile der Finite Elemente Methode (FEM) zu verstehen
- ... 2D- und 3D-FEM-Modellierungen durchzuführen und die Ergebnisse zu bewerten

### **Teaching and Learning Methods:**

Die Veranstaltung gliedert sich in einen "Vorlesungsteil" zu Beginn der Stunde, wobei mit ständiger Unterstützung durch eine Powerpoint-Präsentation eine Einführung in die Theorie und das Modellierungsprogramm gegeben wird. Teilweise erfolgen Erläuterungen als Tafelanschrift. Die verschiedenen Modellierungsprogramme werden im zweiten Teil der Stunde anhand von Übungsblättern im Numerischen Labor am PC von den Studenten angewendet (bearbeitet) und besprochen. Zur Vertiefung bzw. Bearbeitung der Studienarbeiten wird ein studentisches Tutorium angeboten. Dadurch können die Studierenden einen schnellen und selbst erarbeiteten Umgang mit den Lernergebnissen erzielen.

### **Media:**

PowerPoint-Präsentationen, Skript, Übungsskript, Tafelarbeit, Demonstration von Modellierungsprogrammen, eigenständige Arbeit der Studierenden im Numerischen Labor an PCs

### **Reading List:**

ANDERSON, M.G. AND RICHARDS, K.S. (1987). Slope stability: geotechnical engineering and geomorphology, Wiley, Chichester.  
BRUNSDEN, D. AND PRIOR, D.B. (1984). Slope Instability, Wiley, London.  
CHRISTEN, M., KOWALSKI, J. & BARTELT P. (2010). RAMMS: Numerical simulation of dense snow avalanches in three-dimensional terrain. Cold Regions Science and Technology 63: 1–14.  
DORREN, L. K. A. (2003): A review of rockfall mechanics and modelling approaches, Progress in Physical Geography, 26: 69-87.

- DORREN, L., MAIER, B., PUTTERS, U. & SEIJMONSBERGEN, A. (2004): Combining field and modeling techniques to assess rockfall dynamics on a protection forest hillslope in the European Alps.- *Geomorphology*: 57, 151–167.
- DORREN, L. (2010): Rocky for 3D revealed - Description of the complete 3D rockfall model. Association ecorisQ.
- EBERHARDT, E., SPILLMANN, T., MAURER, H., WILLENBERG, H., LOEW, S., & STEAD, D. (2004): The Randa Rockslide Laboratory: Establishing brittle and ductile instability mechanisms using numerical modelling and microseismicity, 9th Int. Symposium of Landslides Rio de Janeiro, 481-487.
- ERISMANN, T.H. & ABELE, G. (2001): Dynamics of Rockslides and Rockfalls. - 316 S., Springer-Verlag (Berlin-Heidelberg-New York).
- GOODMAN & GEN HUA SHI (1985): Block Theory and its application to Rock Engineering. - 338 S., Prentice Hall.
- GOODMAN, R. E. (1995): Block theory and its application.- *Géotechnique*, 45 (3): 383-423.
- HOEK, E. (2000): Practical rock engineering. – 237 S.,
- HOEK (2007): Practical rock engineering. - 237 S.,  
<http://www.rocscience.com/hoek/PracticalRockEngineering.asp>.
- KRUMMENACHER, B., PFEIFER, R., TOBLER, D., KEUSEN, H.-R., LINIGER, M. & ZINGGELER, A. (2005): Modellierung von Stein- und Blocks Schlag – Berechnung der Trajektorien auf Profilen und im 3-D Raum unter Berücksichtigung von Waldbestand und Hindernissen. – 10 S., Zollikofen (pdf-Version).
- ORTIAGO, J. AND SAYAO, A. (2004). Handbook of Slope Stabilisation, Springer, Berlin.
- TURNER, A. K. & SCHUSTER, R. L. [Hrsg.] (1996): Landslides Investigation and Mitigation. - 675 S., Special Report 247, Washington, D.C. (National Academy Press).
- WYLLIE, D.C. & MAH, C.W. (2004): Rock Slope Engineering. Spon Press, London and New York. p. 22-45.  
[http://www.rocscience.com/hoek/corner/Practical\\_Rock\\_Engineering.pdf](http://www.rocscience.com/hoek/corner/Practical_Rock_Engineering.pdf), abgerufen am 11.10.2012.
- Paper zu diversen FE-Themen: <http://www.rocscience.com/products/3/papers>, abgerufen am 11.10.2012.

**Responsible for Module:**

Prof. Dr. Michael Krautblatter, Fachgebiet für Hangbewegungen [m.krautblatter@tum.de](mailto:m.krautblatter@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Numerische Methoden 1 (Grundlagen) (Vorlesung mit integrierten Übungen, 2,5 SWS)

Krautblatter M, Jacobs B, Knapp S, Scandroglio R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV490054: Numeric Analysis 2 - Numerical Modeling | Numerische Methoden 2 - Codes

Version of module description: Gültig ab winterterm 2013/14

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Es wird eine Klausur abgehalten, in der die Studierenden nachweisen müssen, ob sie die erlernten Grundlagen in den Ursachen und Auslösern von Muren und Steinschlägen, den physikalischen Gesetzmäßigkeiten der Bewegung von Muren und Steinschlägen und der Risikoanalyse wiedergeben können. Die Studierenden müssen in der Prüfung fallspezifische Ergebnisse von Simulationen analysieren und bewerten können. Es wird in der Klausur überprüft, ob die Studierenden verstanden haben, welche Eingabeparameter sich wie auf die Simulationsergebnisse auswirken.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Grundkenntnisse in der Klassifikation und Erkennung von Hangbewegungen und in der Geoinformationssoftware ArcGIS. Es wird ein Interesse an der lösungsorientierten Analyse von Naturgefahren im Alpenraum und der dadurch verursachten Gefährdung von wirtschaftlichen Gütern und sozialen Werte erwartet.

Für die Teilnahme an der Prüfung müssen folgende Module erfolgreich absolviert sein (oder vergleichbare Veranstaltungen):

- Hangbewegungen (P-04)
- Numerische Methoden I (W-06)

#### Content:

- Bedeutung von Muren und Steinschlägen
- Definitionen, Begriffe und Klassifikationen von Hangbewegungen
- Ursachen und Auslöser für Hangbewegungen, speziell Murgang und Steinschlag
- Analyse von rezenten Ereignissen, wie z.B. Murgang in Oberstdorf

- Schutzmaßnahmen gegen Hangbewegungen, speziell gegen Murgänge und Steinschläge
- Einführung in die Software RAMMS (Debris flow und Rockfall)
- Modellierung und Analyse verschiedener Szenarien mit der Software RAMMS
- Sensitivitätsanalyse der Inputparameter in Ramms
- Grundlagen der Risikoanalyse

### **Intended Learning Outcomes:**

Die Studierenden sind am Ende des Kurses in der Lage:

- zu verstehen, wo und warum in Bayern Murgänge und Steinschläge auftreten
- zu verstehen, wie Hangbewegungen voneinander differenziert werden können
- zu verstehen, woran Murgänge und Steinschläge in der Natur erkennbar sind und welche Schutzmaßnahmen es dagegen gibt
- zu verstehen, wie das Alter einer Hangbewegung bestimmt werden kann
- zu verstehen, welche physikalischen Gesetzmäßigkeiten dem Ramms-Modell zu Grunde liegen und welche Eingangsdaten für RAMMS benötigt werden
- zu verstehen, wie diese Eingangsdaten gewonnen werden können
- zu verstehen, welche Daten durch die Ramms-Modellierung erstellt werden
- Simulationen in Ramms selbst durchzuführen und deren Ergebnisse zu analysieren
- selbst eine Kalibrierung der Simulation durchzuführen und somit ein Gefühl für die Eingangsparameter zu entwickeln
- selbst eine Sensitivitätsanalyse durchzuführen
- zu verstehen, wie eine Gefahrenzonierung durchgeführt wird
- dieses erworbene Wissen anzuwenden und selbst eine Gefahrenzonierung durchzuführen
- zu verstehen, was Risiko ist und wie es berechnet werden kann
- dieses erworbene Wissen anzuwenden und selbst das Risiko anhand von Fallbeispielen und eigenen Simulationsergebnissen zu berechnen
- eine Kosten-Nutzen-Analyse durchzuführen und zu bewerten welche Schutzmaßnahme wirtschaftlich gesehen optimal ist

### **Teaching and Learning Methods:**

Um die angestrebten Lernergebnisse bestmöglich zu erreichen, wird auf eine Mischung aus verschiedenen Lehr- und Lernmethoden wie Vorlesung mit PPT-Präsentation und Smartboard und Videos zurückgegriffen. Einen Großteil des Kurses arbeiten die Studierenden selbst mit der Software Ramms am PC. Für eine erfolgreiche Nachbearbeitung des Stoffs werden die wichtigsten Arbeitsmaterialien online bereitgestellt.

### **Media:**

PowerPoint-Präsentation, Tafel, Flip-Chart, Smartboard, Prezi-Präsentation, Videos, Gruppenarbeit

### **Reading List:**

- Turner, A.K., Schuster, R.L., 1996. Landslides: Investigation and Mitigation, National Academy Press.

- WSL Institut für Schnee- und Lawinenforschung SLF (Eds.), 2013. RAMMS rapid mass movements simulation - A numerical model for debris flows in research and practice. User Manual v1.5 Debris flow, Davos, Switzerland.
- Christen, M., Bühler, Y., Bartelt, P., Leine, R., Glover, J., Schweizer, A., Graf, C., McArdell, B.W., Gerber, W., Deubelbeiss, Y., Feistl, T., Volkwein A., 2012. Integral hazard management using a unified software environment – numerical simulation tool “RAMMS” for gravitational natural hazards. 12th Congress INTERPRAEVENT 2012, Grenoble, France.
- Bertoldi, G., D’Agostino, V., McArdell, B.W., 2012. An integrated method for debris flow hazard mapping using 2D runout models. 12th Congress INTERPRAEVENT 2012, Grenoble, France, 435-446.
- Schraml, K., Thomschitz, B., McArdell, B.W., Graf, C., Hungr, O., Kaitna, R., 2015. Modeling DebrisFlow Runout Pattern on a Forested Alpine Fan with Different Dynamic Simulation Models. In: Lollino et al. (Eds.). Engineering Geology for Society and Territory – Volume 2, Springer, Switzerland, 1673-1676.
- Berger, C., McArdell, B.W., Lauber, G., 2012. Murgangmodellierung im Illgraben, Schweiz, mit dem numerischen 2D-Modell RAMMS – Murgangmodellierung in der Praxis. 12th Congress INTERPRAEVENT 2012, Grenoble, France, 37-45.
- McDougall, S., Hungr, O., 2004. A model for the analysis of rapid landslide motion across three-dimensional terrain. Can. Geotech. J. 41, 1084-1097.
- BUWAL, 1999 [Hrsg.]. Risikoanalyse bei gravitativen Naturgefahren. Fallbeispiele und Daten, 129 S.
- Rudolf-Miklau, F., 2010. Naturgefahren-Management in Österreich. Vorsorge-Bewältigung-Information. 252 S.

**Responsible for Module:**

Prof. M. Krautblatter, Fachgebiet für Hangbewegungen [m.krautblatter@tum.de](mailto:m.krautblatter@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Numerische Methoden 2 (Codes) (Übung, 3 SWS)

Krautblatter M, Jacobs B, Kiefer C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Field of Study 9: Sustainable Urban Mobility Planning | Vertiefung 9: Sustainable Urban Mobility Planning

### Required Modules | Pflichtmodule

#### Module Description

### BGU52022: Modelling of Environmental Effects in Transportation | Modellieren von Umweltwirkungen im Verkehr [MoDEET]

*Modelling of environmental effects in transportation*

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105   | <b>Contact Hours:</b><br>75                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a scientific paper with a final colloquium.

By means of a scientific elaboration it is examined to what extent the students are able to methodically approach technical-scientific questions in the field of transport-related environmental effects and to assess causes and effects of different emissions in order to be able to answer complex, spatially related questions by means of suitable measures for the sustainable design of transport systems. Furthermore, they show that they can assess these measures by means of a self-developed emission model with the help of various transport, spatial and environmental data. Through the discussion in the colloquium, the students demonstrate that they can relate their given problem in the overall context of transport-related environmental impacts, and that they have understood the interactions with the other fields of action of environmental impacts as well as the higher-level issues, e.g. global climate change.

#### Repeat Examination:

#### (Recommended) Prerequisites:

-

**Content:****Part 1: Transport and the Environment (Lecture):**

- Transport and Air Pollution
- Vehicle Emissions Standards
- Noise
- Consumption of energy
- Climate change
- Sustainable transport

**Part 2: Modelling of Transport Related Emissions (Seminar):**

- Emission models with a focus on environmental and health impacts
- Data analysis and interpretation
- Emission estimation of transport activities
- Emission scenarios (BAU and mitigation)
- Evaluation of emission reduction strategies
- Spatial visualization of the results

**Intended Learning Outcomes:**

After the completion of the module, students are able to:

- know the main environmental effects of traffic
- understand the main traffic related emissions, their sources and their impacts
- know the common emission standards for vehicles and their measurement
- know the relation of sound and noise as well as the health impacts of noise
- know the cause and impact of transport on global climate change
- know definitions and develop measures for sustainable transport systems
- understand the use and development of emission inventories
- know and apply methods for estimating transport related emissions
- model transport emissions
- develop their own emission models and acquire the necessary data
- develop strategies for emission reduction and evaluate those strategies by the means of models
- present the results of their estimations in written and oral form

**Teaching and Learning Methods:**

In a series of presentations, the theoretical basics on anthropogenic environmental impacts and their interrelationships with transportation are conveyed, always with the opportunity for discussion. Additional materials such as images and films are used to better illustrate the input. The seminar work extends the theoretical foundations with practical examples that are transferred into models for emission assessment. Discussions deepen the strategic concepts for emission reductions. Scientifically based methods and modeling approaches are discussed, applied and critically evaluated.

**Media:**

presentations, blackboard

### Reading List:

- Update of the Handbook on External Costs of Transport. Final report. European Commission – DG Mobility and Transport 2014
- Citeair II – Integrated Urban Emission inventories. Final report. European Regional Development Fund
- Grundwissen der Verkehrsökologie. Udo J. Becker 2016
- HBEFA 4.1. Development Report. Infras 2019
- Update of Emission Factors for HBEFA Version 4.1. Institute of Internal Combustion Engines and Thermodynamics 2019
  
- CO2 Emissions from fuel combustion. Highlights. International Energy Agency 2011
- Energy technology perspectives. Scenarios and strategies in 2050. International Energy Agency 2010
- CO2-Emissionsminderung im Verkehr in Deutschland. Mögliche Maßnahmen und ihre Minderungspotentiale. Ein Sachstandsbericht des Umweltbundesamtes. Umweltbundesamt 2010.
- Fortschreibung und Erweiterung "Daten- und Rechenmodell: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2030 (TREMODO, Version 5). IFEU 2010
- Air Quality Management. Sustainable Transport: a sourcebook for policy-makers in Developing cities, Module 5a, revised April 2004, GTZ GmbH
- Reducing Air Pollution from Urban Transport Companion. Ken Gwilliam, Masami Kojima, June 2005,
- THE WORLD BANK; Air Quality Guidelines Global Update 2005. World Health Organization 2006, ISBN 9289021926

### Responsible for Module:

Wulfhorst, Gebhard; Prof. Dr.-Ing.

### Courses (Type of course, Weekly hours per semester), Instructor:

Verkehr und Umwelt (Vorlesung, 2 SWS)

Bogenberger K [L], Tsakarestos A ( Bachmann F, Ilic M )

Modellieren von Umweltwirkungen im Verkehr (Vorlesung, 3 SWS)

Wulfhorst G ( Seisenberger S ), Ilic M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV520007: Land Use and Transport - Interactions and Strategies | Siedlungsstruktur und Verkehr - Wechselwirkungen und Strategien**

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                   |                                      |
|--------------------------------|-----------------------------|-----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105   | <b>Contact Hours:</b><br>75          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination consists of a written, closed book test (60 min) and a project work. The project work will be handed in as a report (ca. 20 pages) and will be presented during the seminar.

The aim of the written examination is to demonstrate that the students understand the principles of interactions of land use and transportation and the different strategies for their common development and can explain those principles in a given short period of time. The students will discuss various concepts of transportation demand management, based on practical tasks, in which they show the properties and limitations of different transport models. They also demonstrate that they understand general accessibility measures as well as their usability in land use and transportation planning.

On the basis of the project work, the students will be able to show that they are able to carry out literature reviews on a given topic, use their findings to address a defined transport planning problem and develop possible solutions. In a presentation they demonstrate their ability to convincingly explain complex topics of land use and transport development in a short period of time and discuss their results with an audience of experts.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

#### **Content:**

Part 1.

- Transport supply, transport demand and impacts of transport
- Interaction of land use and transport

- Accessibility
- Regional land use and transport concepts
- Spatial planning instruments
- short-range mobility
- Introduction to accessibility instruments
- Planning issues in Munich Region
- GIS-based workshops

#### Part 2.

- Introduction to Transportation Demand Management (TDM)
- Expert inputs about a specific TDM related topic
- Working session: How to write a scientific paper
- Working session: Team building, definition of objectives and methods, structuring of papers, timelines
- Students presentations

#### **Intended Learning Outcomes:**

At the end of the course, the participants of the seminar are able to understand the interactions between land use and transportation demand, to analyze and evaluate the traffic demand management and to create concepts for sustainable transport demand management.

Considering methodological aspects, the students are able to perform scientific literature analysis autonomously and gather appropriate literature on the topic. They are prepared to work in groups on complex issues, to design solutions for a given problem, to prepare written scientific contributions and to hold presentations.

Moreover, students are able to evaluate their own and others work through group discussions.

#### **Teaching and Learning Methods:**

The module consists of a lecture and a seminar. Theoretical basics are presented in lectures using a PowerPoint presentation. However, the opportunity for discussion will be given at any time. Other visual media will also be used to improve the presentation of the presented topics. Furthermore, an excursion will take place which aims to gain on-site experience on the relations between land use and transport planning. For single topics guest speakers will be invited.

In the Seminar a topic related to Transportation Demand Management will be introduced through presentations and expert inputs. One or more case studies with potential for sustainable mobility will be presented. Students shall carry out a scientific literature review in groups designing solutions for given mobility drawbacks and present their results by preparing a report and holding a presentation.

Assistance on exam preparation is given during the semester through voluntary individual work in form of written homework (preparation of an essay and exercises). In the middle of the semester a 30-minute test-exam will take place (does not count to the final grade).

#### **Media:**

PPT presentations, handouts, blackboard, scientific essays, guest lectures.

Combination of lectures, exercises including case-study based examples in lecture hall and homework, excursion with experts, guest speakers on selected research and development projects.

**Reading List:**

Vuchic, V. R. (1999). Transportation for livable cities. New Brunswick, N.J.: Center for Urban Policy Research.

**Responsible for Module:**

Wulfhorst, Gebhard; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Seminar (Seminar, 3 SWS)

Kinigadner J, Pfertner M, Xu Y

Interactions of land-use and transport (Vorlesung, 2 SWS)

Wulfhorst G [L], Wulfhorst G, Kinigadner J, Jehle U

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Elective Modules | Wahlmodule

### Module Description

#### AR30213: Urban Development through Mobility | Stadtentwicklung durch Mobilität

Version of module description: Gültig ab winterterm 2019/20

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module consists of a project work. The students show their progress in the project in three group presentations. In the context of the presentations, the students demonstrate their understanding of the interdependence of urban development and traffic planning, the theoretical basic considerations of Transit-Oriented-Development and its transfer to a Munich case study.

The first presentation for the analysis of the study area contributes 20% to the overall grade.

The second presentation shows the results of a charrette (30%). The follow-up documentation of the results with digital tools is shown in a final presentation (50%). Each group participant must contribute to the presentation. Individual grading is ensured by recomposing the groups after each presentation as well as targeted inquiries.

Important notice in consideration of the restrictions on personal contacts due to the CoViD19 pandemic: If the general conditions (hygiene, distance rules, etc.) for an exam with personal attendance can not, or only under disproportionate effort, be ensured, the form of examination can be changed to a written scientific report, optionally together with digital presentations, in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at the latest 14 days before the exam date by the examiner after consultation with the responsible examination board.

#### Repeat Examination:

Next semester

**(Recommended) Prerequisites:**

Architecture students are familiar with the basics of urban planning and design. Engineering students are familiar with the basics of transport infrastructure planning and transit management. Both groups of students must be interested in learning from each other.

**Content:**

Public passenger transport (PT) is an essential element of sustainable urban and regional development. "Urbanity" is the concentration and mixture of different functions in space and often the nucleus of economic development. The triumphant advance of the automobile since the 1950s made it possible to extend the development of the built environment to the detriment of urbanity. The price today is long distances, high infrastructure costs and an increasing burden on the environment in metropolitan regions. Public transport makes a significant contribution to reversing this development.

However, efficient public transport requires a compact settlement body. Vice versa, a densified urban district requires good public transport. Urban development following this pattern is called Transit-Oriented Development (TOD) or integrated urban and transport planning. Analytically, TOD can be prepared using Bertolini's (1999) node-place model. The assumption is that there is a balanced development of an urban environment, if the accessibility with the public transport ('node') and urban functional density ('place') are in balance. The higher the centrality of a traffic junction, the denser the surrounding district should be.

As part of the construction of new transport infrastructure, individual places become more accessible. In addition, new stations also allow new transfer connections, which lead to a redistribution of travel routes and often also the formation of tangential mobility chains.

In this seminar, each semester we look at a selected case study from the Munich area, for which new urban development opportunities arise through public transport infrastructure investment.

**Intended Learning Outcomes:**

After course completion, students will be able to

- understand the interdependency of urban and transit development, - recall the fundamentals of transit oriented development, and
- apply their understanding to a case study in Munich.

**Teaching and Learning Methods:**

The module course consists of three evening lectures of practitioners, an input lecture, a tutoring session, and a workshop. The lectures convey basic knowledge. The workshop serves as a playful exploration of the subject and introduction to interdisciplinary teamwork.

**Media:**

In the evening lectures and the inputs experts from practice and chair staff use digital presentations. The slides of the lectures, basic literature and further material will be made available



on the TUM learning platform. In the workshop, students will build a physical model. In the presentations, students can also rely on digital aids.

**Reading List:**

Bertolini, Luca (1999): Spatial Development Patterns and Public Transport: The Application of an Analytical Model in the Netherlands. In: Planning Practice & Research, 14 (2), 199-210.

**Responsible for Module:**

Prof. Alain Thierstein Prof. Dr. Gebhard Wulfhorst

**Courses (Type of course, Weekly hours per semester), Instructor:**

Stadtentwicklung durch Mobilität (Erreichbarkeit mit dem öffentlichen Verkehr als urbaner Generator) (Seminar, 2 SWS)

Thierstein A, Wulfhorst G, Büttner B, Wenner F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU52016: Evaluation of Transport Projects and Policies | Evaluation von Verkehrsprojekten und -programmen

Version of module description: Gültig ab winterterm 2013/14

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

During the semester, students will be asked to submit a piece of homework (group work) which contributes to 20% of the overall grade. A final written exam will count 80% of the required achievements. Questions in the written exam will be based on the lecture and central pieces of literature, as indicated during the lecture.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Interactions of Land-Use and Transport (ILUT)

#### Content:

1. Rationale of public decision-making
  - a. Difference between public and private investment decisions
  - b. Welfare economics basis of investment
2. External costs and accounting prices in transport
  - a. Valuing time costs in transport
  - b. Valuing transports contribution to climate change
  - c. Valuing local emissions
  - d. Valuing transport safety risks
3. Impact evaluation and evidence-based policies
4. Beyond the independent planner: policy process and evaluation
  - a. Do we need an ethics of planning?

- b. Public choice critique of welfare economics
- c. Transaction costs of politics and transport policy
- d. Interest groups and public investment decisions
- e. Bureaucracy and public decision making

**Intended Learning Outcomes:**

After participating the module, students are expected to be able to:

- understand the normative basis of ex ante evaluation for public decision making,
- assess how to relate policy objectives to planning tools,
- assess the potential of ex post evaluations for decision making,
- explore the main interactions between policy processes and public decision making.

**Teaching and Learning Methods:**

The Module consists of lectures, and video conferenced tutorials. In addition, students are expected to submit a written exposée on one of the topics of the lecture. There will be 2 lecture days. At the end of semester, a final written exam is required.

**Media:**

Lecture Presentations, photocopied relevant literature

**Reading List:**

**Responsible for Module:**

Wulfhorst, Gebhard; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU52020: Accessibility Planning | Erreichbarkeitsplanung [BGU52020]

Version of module description: Gültig ab winterterm 2017/18

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The participants will submit a final report at the end of the semester and held final presentations. Subsequently the examination type is a report. The report will assure that the students gained the knowledge to transfer theories and concepts of accessibility to independently chosen case studies. The presentation will assure that the students are able to clearly state and defend their arguments in front of experts. The written (report) as well as the oral (presentation) will each be accounted for 50% of the grade.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

#### Content:

The content of the module aims to provide the students with an overview of the theories and concepts as well as tools and methods that are available to enable sustainable accessibility planning. The following key areas will be covered:

- Urban and transport planning theories and concepts
- Interaction of land-use and transport planning
- Accessibility indicators and tools (PPS)
- Accessibility planning
- Regional governance und policy-making

**Intended Learning Outcomes:**

After the completion of the seminar, the participants will have acquired the solid methodological background required to conduct scientific sound research based on presentations, guest lectures and state of the art literature research. The participants will be able to classify and relate a number of concepts and theories in the field of accessibility planning (interaction of land-use and transport planning). The participants will be able to formulate their own critical conclusions, while naming further need for research. Additionally, students will acquire the competencies to present their own point of views and be able to discuss/argue.

**Teaching and Learning Methods:**

lecture (presentation slides), guest lectures, discussions, literature research, seminar work; Lectures and on-going discussions explain the thematic basics for the students. For further clarification internationally renowned researchers will be invited to give guest lectures. Students will conduct state of the art literature research on their own with the aim to deepen the knowledge in the field of accessibility planning as well as to point out innovative ideas and need for further research. interactive and dynamic discussions support the learning from each other.

**Media:**

Presentation slides (PPT), whiteboard, literature, readings

**Reading List:**

"Geurs, K., & van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, 12(2), 127-140.

Papa, E., Silva, C., Te Brömmelstroet, M., & Hull, A. (2016). Accessibility instruments for planning practice: a review of European experiences. *Journal of Transport and Land Use*, 57-75.

te Brömmelstroet, M. C. G., Silva, C., & Bertolini, L. (2014). COST Action TU1002- Assessing usability of accessibility instruments. COST.

te Brömmelstroet, M., Skou Nicolaisen, M., Büttner, B., & Ferreira, A. (2017). Experiences with transportation models: An international survey of planning practices. *Transport Policy*, 58, 10-18.

"

**Responsible for Module:**

Wulfhorst, Gebhard; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Accessibility Planning (Seminar, 2 SWS)

Büttner B [L], Büttner B, Nichols A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU56057: Public Transport Concepts, Planning and Operation | ÖPNV-Konzepte, Planung und Betrieb [PTCPO]

Version of module description: Gültig ab summerterm 2021

|                       |                             |                                  |                                      |
|-----------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b>  | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6 | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Prüfung ist eine Klausur von 120 Minuten. Als Hilfsmittel ist nur ein nicht-programmierbarer Taschenrechner erlaubt.

Durch Verständnisfragen wird überprüft, ob die Studierenden, die funktionalen und strategischen Charakteristiken des ÖPNV verstanden haben. Anhand konzeptioneller Fragestellungen weisen die Studierenden nach, dass sie auf ein gegebenes Problem, strategische Lösungen unter Aussuchen von passenden Verkehrsmittel und Netzformen des ÖPNV sowie deren Integration mit anderen Verkehrsmitteln zu entwickeln. Anhand von Berechnungsaufgaben weisen die Studierenden nach, dass sie für gegebene Netze die betriebliche Planung des ÖPNV durchführen und iterativ mit der Netzplanung verknüpfen können.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Grundständige Kompetenzen in Verkehrsplanung, z.B. durch BV000029 "Verkehrstechnik und Verkehrsplanung Grundmodul" oder vergleichbare Module auf Bachelor-Niveau

#### Content:

- Funktionale und betriebliche Charakteristiken von Verkehrsmitteln des ÖPNV
- Typologie und Geometrie von Linien und Netzen
- Integration von Verkehrsmitteln des ÖPNV, intermodale Schnittstellen
- Paratransit und ÖPNV für ländliche Räume
- Beschleunigung des ÖPNV und Erhöhung der Kapazität
- Tarifsystematik und Bezahl-Technologien
- Netzplanung im ÖPNV
- Fahrplanbildung

- Fahrzeugeinsatzplanung
- Fahrereinsatzplanung
- Rückkopplungen und iterative Prozesse in der Betriebsplanung

### **Intended Learning Outcomes:**

Nach erfolgreichem Abschluss des Moduls sind die Studierenden in der Lage.

- funktionalen und betrieblichen Charakteristiken verschiedener Verkehrsmittel des ÖPNV zu verstehen
- funktionalen Charakteristiken verschiedener Netz- und Betriebsformen des ÖPNV zu verstehen
- die Einsatzmöglichkeiten und Einsatzgrenzen verschiedener Verkehrsmittel des ÖPNV für die unterschiedlichen urbanen Problemstellungen zu bewerten
- passende Netzformen und Verkehrsmittel als Lösung für diese Problemstellungen strategisch und betrieblich zu entwickeln
- Systeme des ÖPNV strategisch und funktional ins Spektrum aller urbaner Verkehrsmittel zu integrieren
- die Zusammenhänge zwischen Netzplanung und betrieblicher Planung des ÖPN zu verstehen
- alle Stufen der betrieblichen Planung (Fahrplanbildung, Fahrzeugeinsatz und Fahrereinsatzplanung) im ÖPNV für gegebene Fragestellungen durchzuführen.

### **Teaching and Learning Methods:**

Die Lehrform ist eine Vorlesung mit integrierter Übung. In Vorlesungsterminen werden durch Präsentation mit Anschauungsbeispielen aus der Praxis die theoretischen Grundlagen und Zusammenhänge vermittelt. Freiwillige, kurze e-Tests, die parallel zu den Vorlesungsterminen angeboten werden, unterstützen eine fortlaufende Verständniskontrolle. Themen die konzeptionellen oder rechnerischen Lösungen erfordern, werden neben der Vorlesung auch in Übungen behandelt, in denen die Anwendung der vorgestellten Methoden vorgeführt wird. Begleitend unterstützen freiwillige Hausaufgaben die Studierenden dabei, die Anwendung der Methoden selber auszuführen und durch das gegebene Feedback, das eigene Verständnis zu verbessern.

### **Media:**

PowerPoint-Präsentation, Filme, E-Tests, Hausaufgaben über Moodle

### **Reading List:**

Vukan R. Vuchic; Urban Transit Systems and Technology; John Wiley & Sons (2007)

### **Responsible for Module:**

Bogenberger, Klaus; Prof. Dr.-Ing.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

ÖPNV-Konzepte, Planung und Betrieb (Vorlesung mit integrierten Übungen, 4 SWS)

Bogenberger K [L], Tsakarestos A ( Bachmann F, Dandl F, Zhang Y )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU68007: Applied Transport Modeling | Angewandte Verkehrsmodellierung [Applied transport modeling]

Version of module description: Gültig ab summerterm 2017

|                       |                             |                                  |                                      |
|-----------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b>  | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3 | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination for the module is in the form of a take-home assignment.

The aim of the exam is to demonstrate that the students understood modeling concepts and methods, and that they can develop a travel demand model, use models to assess the impacts of proposed developments, and describe modeling procedures and results in a documentation. The nature of the exam ensures that students are able to independently use the VISUM software in applying the four-step modeling techniques.

Each student submits an Excel file showing the calculations done on the input data, a Visum version file showing the model output, and a written report detailing the modeling procedures and results.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Transport Planning Models (240744419) by Gebhard Wulfhorst and Chenyi Ji

#### Content:

This module introduces students to the practical application of transport modeling concepts using the VISUM transport modeling software. Topics covered include:

- Conduct of household travel survey and data processing
- Processing of transport network data
- Trip generation modeling



- Trip distribution modeling
- Mode choice modeling
- Traffic assignment modeling
- Scenario management
- Extension of modeling software capabilities with scripts

### **Intended Learning Outcomes:**

Upon completion of the course, students are able to use the VISUM software to model travel demand in order to reconstruct existing traffic conditions in an area and assess the effects of future developments and planned traffic measures. Specifically, they are able to...

- understand modeling concepts and methods
- develop a travel demand model
- use models to assess the impacts of proposed developments
- describe modeling procedures and results in a documentation

### **Teaching and Learning Methods:**

A hands-on computer training approach where students complete real-world tasks with the support of the tutor(s). The tasks mimic the modeling process and subsequent tasks build upon previous tasks such that by the end of the final task, each student would have developed a complete travel demand model from scratch using the VISUM software.

For each task, an introduction is given in the form of a short lecture to help students understand the modeling concepts and methods. After the introductory lecture, students use the VISUM Software and put the theory into practice in order to deepen the knowledge that has been learned during the lectures. Here, the capabilities of the VISUM software for each modeling task are learned.

### **Media:**

- PowerPoint Presentations
- PTV VISUM Transport modeling software
- Microsoft Excel and Access

### **Reading List:**

- Ortúzar, J. de D., and Willumsen, L. G. (2011). Modelling Transport (4th ed.). Chichester: John Wiley & Sons.
- Cambridge Sytematics Inc. (2010). Travel Model Validation and Reasonableness Checking Manual Second Edition.
- PTV AG (2016). PTV VISUM 16 Manual.

**Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Applied Transport Modeling with VISUM (Seminar, 2 SWS)

Ji J [L], Ji J, Pukhova A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU68011: Service Concepts and Operation Models for New Mobility Solutions for Mixed-Use Residential Developments | Konzepte und Operationsmodelle für neue Mobilitätslösungen in gemischtgenutzten Siedlungsentwicklungen [Service Concepts and Operation Models]**

Version of module description: Gültig ab winterterm 2019/20

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

One report must be submitted at the end of the semester (80%). Students need to show that they understood the range of mobility concepts that could be implemented at a mixed-use residential development and develop one from the perspective of one stakeholder (real estate developer, mobility service provider, resident, etc.). Special focus will be given to shared mobility services as a complement of public transport and non-motorized modes. Students must demonstrate that they are able to discuss different case-based perspectives on integrated mobility planning and mixed-use residential development and apply them to actual new real estate development projects. The written report will be complemented by a short 10-minute presentation (20%), through which the student will demonstrate their ability to present their main findings and communicate to an audience in the form of a mock client pitch.

The final grade is composed of the grade of the report (80%) and the presentation (20%).

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Transport Sociology and Psychology (Course number 240834759)

#### **Content:**

The aim of this course is to introduce students to mobility concepts that could be required in mixed-use residential developments.

The first half of this course aims to provide students with an overview and critical discussion of current and future urban and district planning best practice and the relevance of transport and mobility planning for district developments and building structures. The initial sessions will

introduce the students to how to quantify and qualify user types and user demands through urban and socio/cultural-demographic analysis as well as trip assessments. Basic principles of user centered design, user mapping, formal and informal mobility mapping will be presented. The module offers the theoretical basis and tools for the development and realization of new approaches and methods towards integrated urban planning. Real case studies will be presented and discussed. The case studies will be selected from international research literature. The discussion will cover the perspectives of different stakeholders (real-estate developer, mobility service provider, resident, city urban planners, etc.).

In the second half of the course, the focus turns on the students, who will apply the gained knowledge to design integrated mobility service solutions. Through cost estimates, analysis of the specific regulatory and stakeholder framework and basic business modeling, the students learn how to conceptualize operative models and specify integrated service packages that add value to the end user and also the real estate developer. This is usually achieved through space gains (less parking) and financial gains (less car dependency).

### **Intended Learning Outcomes:**

After completion of the course, the students understand the methodological basis for the development of mobility concepts for mixed-use residential developments. The students will apply familiar and new interdisciplinary assessment tools and methods from transport planning to problem solving and business modelling in urban planning.

The aim of this course enable the students to design with the principals of transport planning and create integrated, user centered mobility solutions. Students will learn the skill sets necessary to consult potential clients on the benefits of shared mobility solutions, economic implications and operative risks.

### **Teaching and Learning Methods:**

The course is based around weekly interactive seminars. The course will apply different teaching methods from traditional lectures to discussions, group work, desktop research, in-class exercises, and presentation skill training. Students are expected to come prepared and engage actively throughout the semester.

In the first half, the lecturer will present the students literature and case studies, followed by discussion between students. Discussions will be facilitated by short PowerPoint presentations with key aspects, structured questionnaires and group work on some examples.

In the second half, the students will perform group work in teams to develop a mobility concept for a real-life large scale mixed use development. The project – in its early planning stage – is set in an urban/ peripheral location with substantial mobility and transportation demands. Each team will assume the perspective of a different stakeholder, and therefore a unique focus area (i.e. business plan, spatial planning, user segmentation etc.). The lecturer will supervise the students and discuss their intermediate results in the weekly interactive seminars. The outcome of the exercise is the development of different mobility concepts with different focus areas. At the end of the course, students will present their concepts in form of a mock client pitch.

### **Media:**

Various reading materials and handouts, scientific articles, planning documents and websites.  
PowerPoint presentations, whiteboard and exercise sheets may be used in sessions.

### **Reading List:**

Federal Ministry for Economic Cooperation and Development. (2016). Urban Mobility. Strategies for Liveable Cities.

Bormann, R., Gross, M., Holzapfel, H., Luehmann, K., Schwedes, O. (2017). Shaping urban change and promoting sustainable mobility. Friedrich-Ebert-Stiftung ISBN 978-3-95861-952-4.

Eleftheriou, V., Knieling, J. (2017). The urban project HafenCity. Today's Urban and Traffic profile of the area. Executive summary of methodology and traffic research conducted in the region. Transportation Research Procedia 24, 73-80.

Meurs, H.J., van Wee G.P. (2003). Land Use and Mobility: a Synthesis of Findings and Policy Implications. European Journal of Transport and Infrastructure Research 3(2), 219-233.

Banister, D. (2008). The sustainable mobility paradigm. Transport Policy 15(2), 73-80.

Bridge, G., Butler, T., Less, L. (2012). Mixed Communities: Gentrification by Stealth? Policy Press, 372 pp.

Jarass, J., Heinrichs, D. (2014). New Urban Living and Mobility. Transportation Research Procedia 1(1), 142-153.

Cirianni, F.M.M., Leonardi, G. (2006). Analysis of transport modes in the urban environment: an application for a sustainable mobility system. WIT Transactions on Ecology and the Environment 93, 637-645.

Circella, G., F. Alemi, K. Tiedeman, S. Handy and P. Mokhtarian (2018). The Adoption of Shared Mobility in California and Its Relationship with Other Components of Travel Behavior Report, National Center for Sustainable Transportation, United States

<http://www.urban-transport-roadmaps.eu/>

### **Responsible for Module:**

Moeckel, Rolf; Prof. Dr.-Ing.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Service concepts and operation models for new mobility solutions for mixed-use residential developments (Vorlesung, 3 SWS)

Moeckel R [L], Moreno Chou A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU70002: Multimodal and Intermodal Freight Transport | Multimodaler und intermodaler Güterverkehr [Multimodal and intermodal freight transport]**

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The coursework and examination requirements will be based around a structured semester project, in which the students will use suitable modeling tools for the development of a model to predict freight flows at a regional or national scale. A number of tasks will be required for the project execution (data acquisition, assessment and analysis, development of a model, calibration of the model, summarisation of the model outputs). The examination will be conducted with a the submission of a technical report and a personal presentation in which each student will present the semester project work (duration of presentation: 20 min, followed up by 15 minutes of questions and answers). The presentation will be created, presented by and graded for each student individually (even if the project is performed in small groups). Thus, the students demonstrate that they have understood the presented intermodal freight concepts and can independently develop a freight model, including both demand and supply sides, using state-of-the-art software and data.

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

None

#### **Content:**

The content of the module is broken down into two sections, dealing with the fundamental models of freight and logistics, and the main technologies and equipment supporting multimodal and intermodal transport.

Fundamentals of freight and logistics

- Introduction to freight transport and supply chain management
- Freight supply models
- Freight demand models
- City logistics models.

#### Multimodal and intermodal transport

- Loading units and intermodal transport units
- Road, rail and maritime freight transport
- Integrators and air freight
- Container transport and container terminals
- ICT and PCS (Port Community Systems)

#### **Intended Learning Outcomes:**

After completing this module, the participants will be able to estimate the demand for freight transport at the regional and national levels, use common freight demand and supply models, and specify the multimodal and intermodal requirements for serving this demand, including the technological options for each mode.

#### **Teaching and Learning Methods:**

lecture with integrated exercises (presentation slides and whiteboard elaborations), readings, project work, technical visits to multimodal freight facilities;

Lectures and whiteboard demonstrations reveal the importance and function of different building blocks for students. For further clarification real examples of intermodal freight systems will be presented. The project work will combine team work (on the identification of the data sources, and the setup of the models) and individual work (final report and presentation). The project supervision will include predefined fixed milestones, to ensure the smooth progress.

#### **Media:**

Presentation slides, whiteboard, readings

#### **Reading List:**

Suitable research publications will be provided to the class, supplementing the lecture slides and other provided material

#### **Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

#### **Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU70004: Discrete Choice Methods for Transportation Systems Analysis | Diskrete Wahlmethoden für Verkehrssystemanalyse**

*Discrete Choice Methods for Transportation Systems Analysis*

Version of module description: Gültig ab winterterm 2017/18

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The learning outcomes be examined by excercises (Übungsleistungen).

The coursework and examination requirements will will be based on 3 individual homeworks that will aim at demonstrating that the students have understood the concepts presented in the lectures and are able to specify and evaluate discrete choice models using freely available software (such as pythonbiogeme and R). Each exercise will be conceptually stand-alone, i.e. will include one or more related questions/problems, aiming at demonstrating that the participants have grasped the material. Each homework will be graded individually and the final grade will be obtained as the weighted average of the individual grades. The weight of each homework will be indicated on the assignment.

This module is also available to the participants of the TUM Skills Excellence Program. For the participants of this programme there are 20 places available.

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

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#### **Content:**

The module provides the participants with an overview of the tools and methods that are available to specify and estimate discrete choice models for transportation systems analysis. The following key areas will be covered:

- Mathematical Modeling of Behavior



- Logit and probit models
- Model estimation and specification tests
- Model specification
- Experimental design and data collection
- Mixtures/simulation based estimation
- Latent class and hybrid models
- Panel data and models
- Forecasting and aggregation
- Bayesian procedures

### **Intended Learning Outcomes:**

After the completion of the module, the participants will have established a solid knowledge of the theoretical foundations of choice modelling, and they will be able to specify, estimate and interpret a wide range of discrete choice models, such as logit, probit, nested logit, mixed logit, latent class models. They will be able to obtain revealed-preference and stated-preference data as well as create a suitable experimental design, including the questionnaire. The participants will also be able to use available software tools, such as pythonbiogeme and R to evaluate these models.

### **Teaching and Learning Methods:**

Format: Lecture with integrated practical exercises.

Lectures provide the students with the theoretical basics of Discrete Choice Methods, e.g. the various building parts of the models, related experimental designs and the survey data, as a Powerpoint presentation, supported by pictures, possibly films and discussions. Practical calculation tasks from realistic studies and models provide the quantitative methods for the data analysis and modelling of different Discrete Choice Methods and the calculation and interpretation of the model results.

### **Media:**

Presentation slides, whiteboard, readings

### **Reading List:**

Train, Kenneth E. Discrete choice methods with simulation. Cambridge University Press, 2009.

Ben-Akiva, Moshe E., and Steven R. Lerman. Discrete choice analysis: theory and application to travel demand. Vol. 9. MIT Press, 1985.

Louviere, Jordan J., David A. Hensher, and Joffre D. Swait. Stated choice methods: analysis and applications. Cambridge University Press, 2000.

### **Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Discrete Choice Methods for Transportation Systems Analysis (Vorlesung mit integrierten Übungen, 4 SWS)

Antoniou C [L], Antoniou C, Ma T, Rothfeld R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU70005: Transportation Economics | Transportökonomie [Transportation Economics]

Version of module description: Gültig ab winterterm 2017/18

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination type of the module is a project work.

In the project work, a realistic task from the area of the economic evaluation of transport systems (eg congestion charge, infrastructure investments, sharing concepts) is used to check whether the students are able to evaluate the suitability of the different assessment methods presented in the lecture and choose a suitable one for their project. They also show that they can apply the selected methods correctly to the concrete example, quantify them, and use the results to assess the feasibility and the impact of the project. The participants will do midterm and final presentations, and finally submit a written project work. The final grade will be determined as follows: midterm presentation: 15%, final presentation: 35%, written project work: 50%

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

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#### Content:

The module provides the students with an overview of the tools and methods that are available to evaluate transportation systems from an economic point of view. The following key areas will be covered:

- Introduction to Transport Economics
- Demand and Supply
- Equilibrium
- External Interactions
- Projects appraisal
- Transportation Investments

- Pricing
- Freight Economics
- Sharing Economy

**Intended Learning Outcomes:**

After completion of the module, the students will understand the methodological basis for the economic evaluation of transport systems and infrastructure investments. They are able to evaluate the main economic aspects from the field of transportation systems, transportation measures and investments. Additionally, the students are able to apply core theories of transport economy, such as external cost, marginal social cost, cost/ benefit considerations, demand/ supply interactions and elasticities to practical tasks, evaluate projects and use their calculation results for feasibility recommendations.

**Teaching and Learning Methods:**

Format: Lecture with integrated practical exercises;

Lectures provide the students with the theoretical basics of the economical assessment of transportation systems and projects, e.g. the various building parts of the models, their boundary conditions and application fields, as a Powerpoint presentation, supported by pictures, possibly films and discussions. Practical calculation tasks from realistic studies and models as well as the supervision of a project work provide the quantitative methods for quantitative methods for application and calculation of the methods as well as the interpretation of the model results for their use in feasibility and economic impact considerations for projects.

**Media:**

Presentation slides, whiteboard, readings

**Reading List:**

Small, Kenneth. Urban transportation economics. Vol. 4. Taylor & Francis, 2013.

Button, Kenneth. Transport economics. Edward Elgar Publishing, 2010.

Gómez-Ibáñez, José A., William B. Tye, and Clifford Winston, eds. Essays in transportation economics and policy: a handbook in honor of John R. Meyer. Brookings Institution Press, 2011.

**Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Transportation Economics (Vorlesung mit integrierten Übungen, 4 SWS)

Antoniou C [L], Antoniou C, Ezzati Amini R, Rothfeld R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV400009: Land Management and Land Policy | Bodenordnung und Bodenpolitik

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment method is project assessment. The students must present a group work executed the entire module period (1 hour per week) on a topic related to land management and land policy. The topic will be communicated to the students in due time. Through presentations students should demonstrate that they are able to investigate given case study projects. This includes, depending on the topic, objectives of the projects, theoretical and conceptual idea of the project and implementation measures undertaken. Furthermore, the students will analyse and assess the results, and will develop and derive conclusions. The group work will be presented in form of PowerPoint presentation of 10 minutes, by which its scientific quality, comprehensiveness, and appropriateness with regard to the topic assigned will be verified. Furthermore, compliance with all formalities (referencing, use of language, etc) will be considered. The presentation will be followed by question session of 10 minutes. Each student also writes an individual paper. The final mark will be based on both the group work and the individual work (50/50).

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

## **Content:**

### **i. Introduction**

Some basic facts and data on global trends including population growth, distribution of natural resources, wealth and poverty, income and population, consumption and production schemes are provided as a base for further discussion. Different definitions, concepts, measurements and indicators of global land problems will be presented and discussed.

### **ii. Land policy and land governance for sustainable development**

Students will understand the concepts of land tenure system and tenure security. Furthermore, they will learn the importance of a comprehensive land policy and good land governance as a basis for poverty reduction, sustainable resource management and economic growth. They will be introduced to the following crucial elements of a coherent land policy:

- The employment of democratic rules, rules of law and law enforcement, participation and transparency to control power and thus avoid land related corruption, land concentration and land grabbing.
- Conveying a vision of the desired development path.
- Focusing on an evolutionary process of change that supplants social upheaval and revolution, including intensive government-citizen dialogue and dialogue within civil society.

### **iii. Land registration and cadastre system**

During the lecture the students will learn about basic concepts of land registration and cadastre system. They will discuss different country case studies and compare different cadastre and registration systems in the world and they will be familiar with general characteristics of these systems.

### **iv. Rural development issues**

Limited opportunities, inappropriate assets and capabilities, institutional deficiencies, and unbalanced power structures will be identified as main causes for rural mass poverty. The strategic dimensions and the guiding principles of rural development will be introduced and discussed, as there is the economic, social, political and ecological dimension. Furthermore, students will learn about the principles of rural land consolidation as well as about the principles of village renewal.

### **v. Regional and urban development issues**

Positive regional and urban development is committed to promoting sustainable cities, town and countryside that fulfil the promise of development for their inhabitants -- in particular, by improving the lives of the poor and promoting equity -- while contributing to the progress of the country as a whole. Furthermore, lessons on regional and urban development deal with issues such as housing and urban regeneration. Beyond general theories, students are familiar with regional and urban development practices in EU, Germany and Munich.

## **Intended Learning Outcomes:**

After this module the students are able to discuss and recognise the potentials and limits of various international agreements that have been ratified by the international community to protect land and other natural resources in order to regulate their use and to ensure equitable access to them. The

students also appreciate international frameworks for land management and land tenure and are able to analyse topics related to land management and land tenure in line with global and local contexts. Participants also understand the principles of land registration and with different types of cadastre and land register. Furthermore, the students are familiar with diverse implementation aspects of land management.

Students are familiar with development theory as well as development policy and are acquainted with the basic principles and current trends in this field. They are also able to critically discuss theoretical and political approaches as well as their benefits and restrictions. Beyond general theory, students are familiar with concrete concepts for urban and rural development and different approaches including village renewal and land consolidation.

**Teaching and Learning Methods:**

Lecture and seminar are held as type of instruction. Teaching method includes presentation, individual and group works and case studies analysis. Through noted methods students are able to understand land management and land policy framework in different countries. Furthermore, the students are able to analysis different cases with respect to theories and its practice in the field.

**Media:**

PowerPoint presentations and handouts

**Reading List:**

A collection of relevant and up-to-date / recent articles and background reading materials will be handed out during the sessions. In additon, students need to find thier own background materials for both the group work and individual work

**Responsible for Module:**

Dr. Uchendu Eugene Chigbu

**Courses (Type of course, Weekly hours per semester), Instructor:**

Land Policy and Land Governance (Vorlesung, 2 SWS)  
de Vries W [L], Duran Diaz P

Environmental Planning and Land Management - Seminar (Seminar, 2 SWS)  
Duran Diaz P [L], Duran Diaz P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV520008: Land Use and Transportation Modelling | Modellierung von Siedlungsstruktur und Verkehr

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105   | <b>Contact Hours:</b><br>75                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The form of exam for this module is a written exam with the duration of 120 minutes.

The goal is to test –based on distinct theoretical and practical tasks- if the students are able to: understand the potentials and limits of the models; calculate the four-step model; apply transport supply and the four-step model in VISUM software; understand the complex relationships between transport supply, long-term mobility decisions, daily activities and travel demand in the real world together with their respective representations in models; develop and analyze accessibility models; understand the basics of activity-based modelling, selected integrated land-use and transport models, system thinking and system dynamics modelling; evaluate the usefulness of different modelling approaches in a short time span.

The exam requires own formulations and calculations.

This is a closed-book exam. Only the use of a non-programmable calculator is allowed.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

-

#### Content:

- Potentials and limits of model-based working
- Transport Modelling beyond 4-step model, its potentials and limits
- Modelling of transport supply
- Modelling of trip generation
- Gravity model of trip distribution
- Discrete choice model (LOGIT) and application in transportation models, especially modal choice
- Models of traffic assignment



- Land-use Modelling
- Integrated Transport & Land-use Modelling
- Activity-based Modelling
- Accessibility
- Dynamic System Modelling
- System Thinking

### **Intended Learning Outcomes:**

After participating in the module the students are able to:

- Analyze the potentials and limits of model-based working
- Evaluate basic algorithms of trip generation, trip distribution, modal choice and traffic assignment
- Apply those basic algorithms of transportation modelling in the software VISUM
- Understand the complex relationships between transport supply, long-term mobility decisions, every day activities, trip generation, mode and destination choices and traffic volumes in the real world and the challenge of their appropriate representation in models (as a function of the modelling objectives)
- Evaluate the fields of application and the limits of classical sequential travel demand modelling (4 step algorithm)
- Analyze and develop accessibility models
- Understand the basic principles of activity-based modelling, chosen integrated land-use and transport models, systems thinking and system dynamics modelling
- Evaluate the usefulness of different modelling approaches
- Prepare the development further selected modelling approaches in individual work (e.g. project seminar, Master thesis, PhD thesis)

### **Teaching and Learning Methods:**

The module consists of a lecture and an exercise. Combination of lectures, exercises including case-study based examples in lecture hall and homework, computer based development of a full transport demand model excursion with experts, guest speakers on selected research and development projects.

The module is made up of lectures and exercises. The content of the lectures will be conveyed to the students by vivid examples, real and computational models as well as discussions with the students. Beyond that, the lectures shall motivate the students to read further literatures and arouse their contention about the topics. In the exercise, examples with detailed problem setting will be calculated. Besides, on-hand computer training will be given so that the students can apply theories into modern practices.

### **Media:**

PPT presentations, handouts, black board, project examples, students license for standard software, hands-on training

### **Reading List:**

Ortuzar/Willumsen (2006): Modelling transport, 3rd edition. John Wiley & Sons Ltd.;  
list of literature in the course

**Responsible for Module:**

Wulfhorst, Gebhard; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Integrated Land-use and Transport Modelling (Vorlesung, 3 SWS)

Wulfhorst G [L], Wulfhorst G, Büttner B, Nichols A, Jehle U

Transport Planning Models (Übung, 2 SWS)

Wulfhorst G [L], Wulfhorst G, Pfertner M, Duran Rodas D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV520009: Project Appraisal and Planning Processes in Transportation | Projektbewertung und Planungsprozesse im Verkehr**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105  | <b>Contact Hours:</b><br>75          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination consists of a 120-minute written exam. In the written exam students demonstrate without helping material and under time pressure that they have understood concepts of transport economy and of economic assessment methods and can depict those aspects in a compacted form. Furthermore they illustrate solutions for different application scenarios. Additionally they demonstrate their ability to explain the basics of planning procedures, the transport policy and its impact, costs and financing as well as realization and evaluation of projects.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

-

#### **Content:**

This module deals with planning processes and project appraisal in transportation. First, the basic principles and concepts of transport economy and system assessment will be introduced. The emphasis is set on environmental and economic assessment tools regarding transportation. Students learn theories and methods to evaluate the environmental impacts in matters to transportation. Basic concepts are applied to actual examples. Moreover, economic assessment methods like the Cost-Benefit-Analysis (CBA) or Multi-Criteria-Analysis (MCA) as well as corresponding applications are introduced and constraints of specific assessment procedures are discussed. Furthermore, concepts of travel demand, costs and technology will be presented and discussed within the context of transport economics.

Besides, this module deals with strategic planning on international/national as well as local/regional level. Further topics are

project development and approval, feasibility studies and environmental assessment. Students will also learn about financing and realisation of transportation projects as well as regional governance participation.

### **Intended Learning Outcomes:**

At the end of the module students are able to analyze and interpret the multi-level connection of environmental and economic aspects of transportation. For example, from the economic point of view students are able to identify an appropriate assessment method and to apply it correctly. Furthermore, they understand the relevant steps of a planning process. The students are also able to define important terms within the area of transport economy and economic assessment methods.

Moreover the students are able to

- identify the formal and informal planning instruments, participation procedures, feasibility studies, costs and financing of transportation projects, their realization and evaluation in Germany and Europe;
- apply the theories and basics of planning and transportations policies;
- apply basic elements of planning to many different contexts;
- identify the main factors influencing planning policies and design mobility concepts.

### **Teaching and Learning Methods:**

The module consists of two lectures and an exercise. During the lectures the content is provided via presentations, PowerPoint slides and interactive discussions. Practical examples including calculations illustrate the theoretical basics. Group work and exercises allow the deeper understanding using additional examples. The students are inspired to improve the acquired knowledge by studying the suggested literature.

### **Media:**

Presentation (handouts), multimedia online tools

### **Reading List:**

Blauwens, G.; De Baere, P.; Van de Voorde, E. [2008]: Transport Economics. Third Edition. De Boeck, Antwerpen.

Haezendonck, E. [2007]: Transport Project Evaluation - Extending the Social Cost-Benefit Approach. Edward Elgar, Cheltenham, Northampton.

Varian, H. R. [2006]: Intermediate Microeconomics - A Modern Approach. Seventh Edition. W. W. Norton & Company, New York, London.

Edwards-Jones, G.; Davies, B.; Hussain, S. [2000]: Ecological Economics - An Introduction. Blackwell Science, Oxford.

### **Responsible for Module:**

Bogenberger, Klaus; Prof. Dr.-Ing.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Transport Economy and System Assessment (Lecture) (Vorlesung, 2 SWS)

Bogenberger K [L], Spangler M ( Fehn F, Hamm L, Weikl S )

Transport Economy and System Assessment (Exercise) (Übung, 1 SWS)

Bogenberger K [L], Spangler M ( Fehn F, Hamm L, Weikl S )

Transportation Policies and Project Design (Vorlesung, 2 SWS)

Wulfhorst G, Duran Rodas D, Horlemann J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV560011: Governance | Governance

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Students will be graded based on a scientific seminar paper and a presentation.

The goal of the term paper is to test students understanding of a set of key concepts concerning governance, as well as to test them on their ability to apply a governance approach independently to a case study and to develop insights that are relevant to practitioners and/or the expert community and academia.

Students will conduct research on and write the term paper independently of the seminar. They will be expected to structure the paper in terms of a social science academic paper, that is with a relevant problem statement, question or key argument, brief state-of-the-art, methodology (including analytical approach), case study and analysis, key findings and insights (theoretical and practical) for a specified audience.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Vorkenntnisse in Verkehrsplanung und Verkehrspolitik

#### Content:

Transport planning is much more than paper work. It is working with people, institutions, companies and so forth. It is also about bargaining and negotiating on better and more effective solutions for transport problems. The paths to sustainable transport demand management on the regional level go along with new concepts of power management and government. Governance is one of the major catchwords to describe the fundamental changes in the relations of political, economic and civil society actors in cities and regions.

Four central topics will shape the lectures and discussions in the class this semester. All topics are closely related to the planning and politics of transport and mobility in cities:

- What is governance? An introduction to the governance debate

- Who's in charge? The changing role of the state
- Who decides? Politics, democracy and the public
- How to decide? Consultation, participation and expertise

### **Intended Learning Outcomes:**

After attending the module, students are able to identify and actively communicate and apply key concepts of governance to current debates and issues in the transport sector.

They will be aware of the range of concepts and theoretical approaches concerning the topic of governance, including, but not limited to: the changing role of the state in the transport sector; key actors in governance; issues like democracy, accountability and legitimacy in governance; the role of the public and expert opinion; and different types (e.g. hierarchical, communities, networks, market, etc.) and processes (e.g. collaborative, technocratic, grassroots, etc.) of governance present in everyday planning and policy in the transport sector.

Further, they will be able to analyze actual policy problems and case studies using a governance perspective and to formulate relevant insights.

### **Teaching and Learning Methods:**

The course is an active mix of lecture, discussion, student presentation, in- and out-of-class activities and readings, in order to facilitate a proper learning of governance theories alongside their application in the analysis of everyday processes of policy-making and planning.

The lectures will be supported with traditional PowerPoint presentations, the blackboard and other materials when necessary.

Discussion will take place in a "round table setting", bringing in the interests and issues students are faced with in their studies, project-work and professional life.

Student presentations will be organized in groups of 2-3 students, and based on readings and related topics from the module. Each student will present once.

In- and out-of-class activities will be based on the application of governance themes and approaches to real-life situations and other case studies.

In addition, students will be asked to read a set of relevant theoretical and practical articles on governance in the transport sector before attending lectures and student presentations.

### **Media:**

Reader, PowerPoint presentations, material for in-class activities, blackboard.

### **Reading List:**

Bang, H.P. (Ed.), 2003. Governance as Social and Political Communication. Manchester University Press, Manchester.

Bevir, M., 2009. Key Concepts in Governance. SAGE Publications Ltd.

Fischer, F., 2009. Democracy and expertise: Reorienting policy inquiry. Oxford University Press, Oxford.

Henderson, J., 2013. Street fight: the politics of mobility in San Francisco. University of Massachusetts Press, Amherst.

Geels, F., Kemp, R., Dudley, G., Lyons, G. (Eds.), 2012. Automobility in transition?: A socio-technical analysis of sustainable transport. Routledge, London.

Meadowcroft, J., 2007. Who is in Charge here? Governance for Sustainable Development in a Complex World. *Journal of Environmental Policy & Planning* 9, 299–314.

Newman, J. (Ed.), 2005. *Remaking governance: peoples, politics and the public sphere*. Policy Press, Bristol.

Peters, B.G., 2011. Governance as political theory. *Critical Policy Studies* 5, 63–72.

Pierre, J., Peters, G.B., 2000. *Governance, politics and the state*. Macmillan Press Ltd., Hampshire.

Wagenaar, H., 2011. *Meaning in action?: interpretation and dialogue in policy analysis*. Sharpe, Armonk, NY.

**Responsible for Module:**

Wulfhorst, Gebhard; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Governance (Vorlesung, 3 SWS)

Scotellaro L [L], Scotellaro L, Zimmer C ( Scotellaro L )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### ED150004: Mixed Methods Procedures for Mobility Research | Mixed Methods Procedures for Mobility Research [MixMethods]

*MixMethods*

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module is examined by a report and an associated presentation (approx. 10 minutes).

The report summarizes four homework-based tasks, which are either written assignments (approx. 5 pages each, without annex) or posters (DINA1). Two homeworks refer to quantitative methods and two homeworks refer to qualitative methods. With the report, students prove that they are able to apply both quantitative and qualitative methods to mobility-related topics, analyze the results, and present their findings in a scientifically sound manner (e.g. conduct the common methods of mobility-related data research in a step-by-step, application-oriented manner, distinguish empirical approaches and assess their applicability to mobility projects).

With the presentation, students demonstrate that they are able to present their findings to an audience in a comprehensible manner (process, visualize and analyze data).

The report counts 80% towards the module grade and the presentation counts 20% towards the module grade.

The assignments will be carried out as individual work. Group work sessions might occur during the module, but will not be graded.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

none

#### Content:

The module covers common methods of mobility research that play an important role in project work as well as in the context of theses. The following contents will be covered in the module:

- Introduction to qualitative as well as quantitative methods of empirical research in the context of urban mobility (e.g., surveys, interviews, social media analysis, stakeholder analysis and other descriptive / multivariate statistical analyses)
- Independent conception and implementation of empirical studies
- Development of research questions in the field of urban mobility
- Design of a suitable research design, including selection procedure, data management, analysis, and applicability
- Execution of all steps of an empirical study from the definition of a problem to the analysis of the data

### **Intended Learning Outcomes:**

After successfully completing this module on qualitative and quantitative methods for mobility research, students will be able to:

- conduct the common methods of mobility-related data research in a step-by-step, application-oriented manner,
- distinguish empirical approaches and assess their applicability to mobility projects,
- describe and design empirical research processes,
- derive hypotheses and formulate them in a testable way, (methodological competence / conceptual thinking),
- derive empirically validated decisions,
- process, visualize and analyze data

### **Teaching and Learning Methods:**

The module takes place in the form of lectures and exercises. There is a balanced ratio of attendance time and self-study time, including both individual work and group work.

The lectures provide helpful scientific, but also application-oriented methodological building blocks for the different phases of empirical research (planning, implementation, and evaluation). The lecturers show the students, how they can process, visualize and analyze data.

Several learning materials from the topic area of urban mobility will illustrate the complexity of the methodological modules. This is to learn how to conduct the common methods of mobility-related data research in a step-by-step, application-oriented manner and distinguish empirical approaches and assess their applicability to mobility projects.

In the exercises, students learn how to apply these methods to specific topics in mobility research, for example in order to derive hypotheses and formulate them in a testable way, (methodological competence / conceptual thinking) and empirically validated decisions.

### **Media:**

Literature (OPAC), presentations (PowerPoint), (online) whiteboard

### **Reading List:**

Adams, J., Khan, H. & Raeside, R. (2014). Research Methods for Business and Social Science Students: Vol. Second edition. Sage Publications Pvt. Ltd.

Baran, M. L., & Jones, J. E. (Eds.). (2020). Applied Social Science Approaches to Mixed Methods Research. IGI Global. <http://doi:10.4018/978-1-7998-1025-4>

Bryman, A. (2015). Social Research Methods (5th ed.). Oxford University Press.

Berg, B. L., & Lune, H. (2012). Qualitative research methods for the social sciences (8th ed.). Pearson.

Creswell, John W., and J. David Creswell. Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications, 2017.

Irizarry, Rafael A. Introduction to data science: data analysis and prediction algorithms with R. CRC Press, 2019.

Ismay, Chester, and Albert Y. Kim. Statistical inference via data science: a ModernDive into R and the tidyverse. CRC Press, 2019.

Wickham, Hadley, and Garrett Golemund. R for data science: import, tidy, transform, visualize, and model data. " O'Reilly Media, Inc.", 2016.

In addition to the mentioned literature, further readings depend on the respective topic.

**Responsible for Module:**

Wulfhorst, Gebhard; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Qualitative Research Methods (Seminar, 2 SWS)  
Duran Rodas D, Büttner B, Aumann S, Grundel M

Quantitative Research Methods (Seminar, 2 SWS)  
Duran Rodas D, Büttner B, Xu Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Field of Study 10: Transportation Engineering and Control | Vertiefung 10: Transportation Engineering and Control

### Required Modules | Pflichtmodule

#### Module Description

### **BV560023: Intelligent Transport Systems | Intelligente Verkehrssysteme [ITS]**

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The evaluation consists of a written exam with a duration of 120 minutes. The students demonstrate their ability to independently identify traffic problems within the field of ITS in a given amount of time and reach a solution without the use of aid materials. The exam checks, if the student remembers and understands the different types of system architectures for intelligent transport systems, as well as adaptive traffic signal control systems, traffic management and traffic control systems. In addition, proposals for systems have to be analysed, evaluated and, if necessary, alternatives have to be developed. The test consists of factual and understanding questions as well as practical tasks. A formulary containing the aspects discussed in the lecture and tutorials will be provided for the exam.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Traffic Management (BV560024)

#### **Content:**

The module combines detailed information on traffic control and traffic management systems with relevant basics on system architectures as well als software tools relevant for practical applications. The contents are organized in the structure to follow:

#### Basics of Traffic Extension:

- Basics of control and system theory
- Urban Traffic Control
- Motorway Traffic Control
- Tunnel Control Systems
- Automated Merto Systems
- Public transport prioritization in urban traffic control
- Quality Management of traffic control
- Research and development in ITS for traffic control

#### ITS System Architectures and Applications:

- Introduction, ITS System Architectures
- International, national and regional architectures
- ITS architectures for individual transport
- ITS architectures for public transport
- ITS architectures for freight transport
- Urban Roadside ITS Infrastructure
- Vehicle technologies for ITS architectures
- Connected, coordinated and automated mobility (CCAM)

#### Intended Learning Outcomes:

After participating in the module, students understand various approaches and technologies used for traffic control on highways and in urban areas, the integration traffic information and management and the management of traffic supply and demand. The students understand the basics of system control theory and can use this understanding to comprehend control-based traffic management measures in urban areas and on highways. They are able to apply selected control methods on practical tasks. Additionally, students understand the design of ITS system architectures, covering several modes, including individual transport, public transport, and freight transport. They get to know the theoretical structure as well as practical applications. ITS architectures and requirements from various countries around the world are presented and discussed. The students understand which roadside infrastructure and vehicle technology is needed for the systems and are able to develop their basic structure.

#### Teaching and Learning Methods:

The module consists of 2 lectures with integrated excercises. The regular lectures will be supplemented by guest lectures given by external experts working in the field. The lectures are given with presentations. Besides, the instructor will use a portion of the time to solve examples for the students, and students will have the remainder of the time to solve problems individually.

#### Media:

Powerpoint presentations, exercise assignments, films, softwarebased examples in computer seminars

**Reading List:**

BAST (2012): Technische Lieferbedingungen für Streckenstationen - TLS 2012. Bundesanstalt für Straßenwesen, Bergisch-Gladbach. [https://www.bast.de/BAST\\_2017/DE/Verkehrstechnik/Publikationen/Regelwerke/Unterseiten/V5-tls-2012.pdf?\\_\\_blob=publicationFile&v=1](https://www.bast.de/BAST_2017/DE/Verkehrstechnik/Publikationen/Regelwerke/Unterseiten/V5-tls-2012.pdf?__blob=publicationFile&v=1)

DIN EN ISO 9001:2015-11 (D/E) Quality management systems - Requirements (ISO 9001:2015); German and English version EN ISO 9001:2015

**Responsible for Module:**

Bogenberger, Klaus; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

ITS System Architectures and Applications (Vorlesung mit integrierten Übungen, 2 SWS)  
Antoniou C [L], Antoniou C, Ma T

Verkehrssteuerung - Vertiefung (Vorlesung mit integrierten Übungen, 2 SWS)  
Bogenberger K [L], Bogenberger K ( Dandl F, Grigoropoulos G, Metzger B ), Spangler M ( Amini S, Grigoropoulos G, Metzger B )  
For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV560024: Traffic Management | Verkehrsmanagement [TM]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The evaluation includes a written examination of 120 minutes, in which the student should demonstrate an ability to independently identify the problem in a given amount of time and reach a solution without the use of aid materials. The test consists of factual and understanding questions that cover the entire lecture material and all the exercises, but focus mainly on the material covered in the tutorials. All questions must be completed without the use of aid materials. The students apply their acquired basic knowledge about the theory of traffic flow and traffic control. A formula sheet containing the necessary formulas discussed in the lecture and tutorial will be provided for the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in traffic engineering, traffic control and transportation planning e.g. Traffic Engineering and Transport Planning-Basic Module and Traffic Engineering and Transport Planning-Supplementary Module

#### Content:

The compulsory course consists of two courses. The lecture will be supported by practical exercises whenever possible, in which students will apply taught skills and methods to solve problems independently. The four lecture parts contain the following content:

##### Course 1: Traffic Flow Theory

- Introduction to traffic flow (Variables of traffic flow, measurement principles, time-space diagrams, stochastic distributions)
- Cross-sectional data (local vs momentary mean speed, fundamental diagram, cumulative plots)

- Spatio-temporal traffic dynamics on motorways and in urban areas (Contour plots, congestion formation and classification, empirical data, macroscopic fundamental diagram, urban congestion)
- Macroscopic traffic flow models & Cellular Automaton (Continuum theory & Lighthill-Whitham-Richards, Shock waves, Cell Transmission Model, Cellular Automaton)
- Microscopic traffic models, and models for pedestrians and bicyclists (Car-following, lane changing, social force model)
- Delay and origin-destination estimation (Queuing theory fundamentals, deterministic models, stochastic models, van zuylen estimation, furness procedure)

#### Course 2: Traffic Control - Basics

- Introduction to navigation systems and routing algorithms
- Quality assessment of dynamic traffic information
- Introduction to control theory
- Traffic management on motorways
- Urban Traffic Control
- Public Transport Control, Passenger Information
- Parking management systems
- Congestion pricing

#### **Intended Learning Outcomes:**

At the end of the course traffic flow theory students are able to

- understand the basic concepts of and the theory behind traffic flow
- evaluate the quality of traffic flow on highways and in urban cities.
- understand the variety of modelling approaches for traffic flow.
- apply the most important macroscopic and microscopic traffic flow models, delay models, and models to estimate origin-destination relations at the intersection level.

At the end of the course traffic control basics students will learn

- the basics concepts of control theory and traffic management in motorways and urban roads
- different routing algorithms and navigation concepts in road networks
- quality assessment concepts for evaluation of dynamic traffic information
- the fundamentals of control theory in traffic engineering
- design and evaluate traffic signal operation at isolated intersections and traffic signal coordination along arterial "green wave"
- main principles of traffic management systems in motorways such as ramp metering
- the role of ITS in the operation of public transport systems
- fundamentals of parking management systems and congestion pricing schemes for cities

At the end of the course, the students will have an understanding of the transportation systems in Germany. They know and understand the specific aspects influencing today's transportation system. The students are able to apply this knowledge to their specific academic fields of interest.

#### **Teaching and Learning Methods:**

The module consists of lectures and accompanying tutorials. In addition, an excursion will be organized that supports the topics covered in the course. The regular lectures will be



supplemented by guest lectures given by external experts working in the field. The lectures are given with presentations. In the tutorials, the instructor will use a portion of the time to solve examples for the students, and students will have the remainder of the tutorial time to solve problems individually.

**Media:**

Powerpoint presentations, exercise assignments, films, excursion

**Reading List:**

Bogenberger, Bertini, Boice [2006] Analytische Methoden zur Interpretation von Verkehrsdaten, Straßenverkehrstechnik

Brilon W, Geistefeldt J, Regler M [2005] Reliability of freeway traffic flow: a stochastic concept of capacity.

Karl, Kessler, Bogenberger [2019] automated classification of different congestion types

Knoop, V [2018] Introduction to Traffic Flow Theory

Treiber & Kesting [2013] Traffic Flow Dynamics - Data, Models and Simulation

Daganzo, C [1997] Fundamentals of Transportation and Traffic Operations

Rempe, Huber, Bogenberger (2016) Spatio-temporal congestion patterns in urban traffic.

Transportation Research Procedia

Geroliminis, Zheng, Ampountolas (2014) A three-dimensional macroscopic fundamental diagram for mixed bi-modal urban networks. Transportation Research Part C

Geroliminis & Daganzo (2008) Existence of urban-scale macroscopic fundamental diagrams: Some experimental findings. Transportation Research Part B

Tilg, Amini, & Busch (2020) Evaluation of analytical approximation methods for the macroscopic fundamental diagram. Transportation Research Part C

Loder, Ambühl, Menendez, Axhausen (2019) Understanding traffic capacity of urban networks. Scientific Reports 9

Helbing, D., & Molnar, P. (1995). Social force model for pedestrian dynamics. Physical review E

Gipps, P.G. [1981]: A behavioural car-following model for computer simulation

Herz, R.; Schlichter, H.; Siegener, W. [1992]: Angewandte Statistik für Verkehrs- und Regionalplaner

Webster, F. V. (1958). Traffic signal settings, road research technical paper no. 39. Road Research Laboratory.

Willumsen, L. G. (1978). Estimation of an OD Matrix from Traffic Counts—A Review.

Van Zuylen, H. J., & Willumsen, L. G. (1980). The most likely trip matrix estimated from traffic counts. Transportation Research Part B: Methodological

Van Zuylen, H. J. (1981). Some improvements in the estimation of an OD matrix from traffic counts.

Highway Research Board [2000]: Highway Capacity Manual

Kerner, B. S. [2004]: The Physics of Traffic

Kotsialos, A.; Papageorgiou, M.; Mangeas, M.; Haj-Salem, H. [2000]: Coordinated and integrated control of motorway networks via non-linear optimal control

Lighthill, M. J.; Whitham, G. B. [1955]: On Kinematic Waves. II. A Theory of Traffic Flow on Long Crowded Roads

Leutzbach, W. [1988]: Einführung in die Theorie des Verkehrsflusses

Nagel, K.; Schreckenberg, M. [1992]: A cellular automaton model for freeway traffic.

Orcutt, F. L. [1993]: The Traffic Signal Book

Papageorgiou, M. [2000]: Regelungsstrategien für den Straßenverkehr - Vergangenheit, Gegenwart und Zukunft

Piszczyk, S.; Dinkel, A.; Leonhardt, A.; Mutzbauer, J. (2007): Testfeld für die Erfassung von Umfelddaten in Streckenbeeinflussungsanlagen

Schnabel, W.; Lohse, D. [1997]: Grundlagen der Straßenverkehrstechnik und der Verkehrsplanung Band 1 & 2

Wang, Y.; Papageorgiou, M. [2005]: Real-time traffic state estimation based on extended kalman filter. A general approach.

Wardrop, J. G. [1952]: Some theoretical aspects of road traffic research

Wiedemann, R. [1974]: Simulation des Straßenverkehrs

**Responsible for Module:**

Tilg, Gabriel M.Sc.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Grundlagen der Verkehrssteuerung (Vorlesung mit integrierten Übungen, 2 SWS)

Bogenberger K [L], Bogenberger K ( Amini S, Sautter N ), Spangler M ( Amini S, Sautter N )

Verkehrsflusstheorie (Vorlesung mit integrierten Übungen, 2 SWS)

Bogenberger K [L], Bogenberger K ( Rostami Shahrabaki M, Tilg G ), Spangler M ( Rostami Shahrabaki M, Tilg G )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Elective Modules | Wahlmodule

### Module Description

#### BGU56048: Traffic Data Collection and Analysis | Verkehrsdaten - Erfassung und Analyse [TD-C&A]

Version of module description: Gültig ab summerterm 2017

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The evaluation includes a written examination of 60 minutes, in which the student should demonstrate an ability to independently identify the problem in a given amount of time and reach a solution without the use of aid materials. The test consists of factual and understanding questions as well as calculatory questions that are oriented towards the exercises. All questions must be completed without the use of aid materials. The exam checks, if the student remembers and understands the different types of traffic sensors (local, stationary route based, on-board) as well as environmental sensors. In addition, proposals for systems have to be analysed, evaluated and, if necessary, alternatives have to be developed. In case of complex calculatory questions, a formula sheet containing the necessary formulas discussed in the lecture and tutorial will be provided for the exam.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Profound knowledge of intelligent transport systems and traffic flow theory as being presented in the following TUM-modules:

- Traffic Engineering and Transport Planning Basic Module (BV560029)
- Traffic Engineering and Transport Planning Supplementary Module (BV000047)
- Modeling and Control of Traffic Flow (BGU56045)

#### Content:

The lecture consists of a theoretical background and its practical application in the field of acquisition and processing of traffic data.

The contents of teaching consist of:

- Local and spatial traffic data acquisition
- Environmental data acquisition
- Floating Car Data
- Routing and map matching
- Methods for traffic data analysis
- Implementation of field tests (e.g. using automated number plate recognition)

**Intended Learning Outcomes:**

After participating in the module, the students are able to:

Develop, conduct and analyze field tests for the acquisition of traffic and environmental data and to use modern traffic detection systems.

**Teaching and Learning Methods:**

The module consists of lectures and a seminar with project work. The contents of the lectures are given in an oral presentation using power point slides. The seminar teaches methods and introduces measurement equipment that will be used in a field test resulting in a project work.

**Media:**

PowerPoint, study trips, demonstrating and applying detection equipment.

**Reading List:**

AST (2002): Technische Lieferbedingungen für Streckenstationen (TLS). Bundesanstalt für Straßenwesen (HRSG), Köln, 2002.

FGSV (2001): Handbuch für die Bemessung von Straßenverkehrsanlagen (HBS).

Forschungsgesellschaft für Straßen- und Verkehrswesen e.V., Köln, 2001

**Responsible for Module:**

Dr.-Ing. Spangler, Matthias

**Courses (Type of course, Weekly hours per semester), Instructor:**

Verkehrsdaten - Erfassung und Analyse (Seminar, 3 SWS)

Bogenberger K [L], Dumler K ( Dandl F, Spangler M ), Glöckl U ( Dandl F, Spangler M ), Spangler M ( Dandl F, Dumler K )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU56055: Autonomous Vehicles and Transportation Systems | Autonome Fahrzeuge und Verkehrsmittel [AVTS]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module is completed with a written exam of 60 minutes. It is allowed to use a self-composed hand-written sheet of DIN A4 paper (front and back side). On the basis of facts and comprehension questions, which require an independent formulation of answers, the students should show that they have understood the aspects of the intelligent, communicating vehicles in connected traffic and that they are able to differentiate the individual technical principles and components of the overall system in a simple, reproducible way.

#### Repeat Examination:

#### (Recommended) Prerequisites:

none

#### Content:

Basics: Introduction to and definition of Automatic Driving Assistance System, Intelligent Transport Systems (ITS) and Cooperative Systems in Transport, impact on transport system and driver (comfort, active safety, efficiency...), driver-environment interaction

- ADAS Functions: Classifications of ADAS functions, automatic control engineering, autonomous driving
- Sensor technology: Detection, data fusion, radar, video etc
- MMI: Man-machine interaction, display and operation concepts, psychology of perception, driving simulator
- Navigation: Coordinate systems for navigation, map matching, positioning, route planning, guidance
- Ensuring of ADAS: Ensuring functions of ADAS concepts, assessment of functions, legal aspects

- ADAS, insights into practical applications: coordination of passive and active safety, accident research

**Intended Learning Outcomes:**

At the end of the module students is able to:

- remember the current trends in the automobile industry as to development of connected and (partially) automated vehicles
- differentiate vehicle sensors needed in such driving tasks
- denominate the state of the art in human-machine-interfacing in the field of driver assistance systems
- assign possibilities of GPS-based and sensor-based navigation
- characterize the employment of driver assistance systems in safety-critical and legal contexts

**Teaching and Learning Methods:**

The Module consists of a lecture. The main part are presentations. For some of the topics, external experts are invited to present the state of the art. The lectures are backed up by presentation slides which are made available online or are handed out to the students.

**Media:**

Presentations

**Reading List:**

Bishop (2005): Intelligent Vehicle Technology and Trends, Artech House, London

**Responsible for Module:**

Bogenberger, Klaus; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Autonome Fahrzeuge und Verkehrsmittel (Vorlesung, 3 SWS)

Bogenberger K [L], Bogenberger K ( Spangler M ), Spangler M ( Dandl F )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU56056: Urban Ropeways | Urbane Seilbahnen [URW]

Version of module description: Gültig ab winterterm 2020/21

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam is a 60-minute written examination. At the same time we offer a 60-minute Proctorio exam. Only a non-programmable calculator is allowed as an aid.

Students are evaluated by means of comprehension questions on their understanding of different cable car systems and their components. Students demonstrate by means of conceptual questions that they are able to assess the suitability of cable car systems in various urban areas, to establish a preliminary alignment for such a system, and to name methods for estimating demand. Given applied use cases, they demonstrate that they can develop strategic solutions for the integration of cable cars with other means of transport. Students demonstrate by means of calculation tasks that they can solve simple design tasks. They also demonstrate knowledge of the legal framework and general regulations for the approval of cable car systems.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basic knowledge of traffic planning and transport engineering, e.g. from basic module Traffic Engineering and Transport Planning or equivalent modules

#### Content:

- Basics of ropeway technology
- Types of cableway
- Technical components of cableways
- Cable car calculations
- Traffic modelling
- Legislative framework

Worldwide practical examples"

### **Intended Learning Outcomes:**

After successful completion of the module, students are able to

- understand the various ropeway systems and their characteristics,
- describe the components of ropeway systems and their function and mode of operation,
- discuss the suitability of ropeway types for a given use case,
- categorise existing demand and urban space structures according to their suitability for the use of cableways,
- establish preliminary alignments for cableway lines, including the necessary specifications, such as the height, location, and type of pillars and stations,
- perform simple dimensioning of a cable car system for a use case,
- identify requirements for operational integration and necessary adjustments to other public transport systems,
- specify the legal framework for an urban cableway system.

### **Teaching and Learning Methods:**

The teaching form is a lecture with integrated exercises. In lectures, the theoretical basics and connections are conveyed through presentations with illustrative examples from practice. Based on the theoretical principles, practical examples of their application in the routing and dimensioning of urban ropeways are dealt with through integrated exercises. An excursion to a ropeway will be carried out.

### **Media:**

PowerPoint Presentation, one excursion

### **Reading List:**

Moderne Seilbahnsysteme eröffnen neue Wege für die Mobilität in unseren Städten – H. Monheim, Ch. Muschwitz, W. Auer, M. Philippi

Elmar Dorigatti, Die Welt der Seilbahnen: Hightech, Rekorde, Faszination (Deutsch) Gebundene Ausgabe – 3. Dezember 2019

Witfrida Mitterer, Immer auf Draht - Seilbahnen vernetzen die Berge (Deutsch) Broschiert – 28. Januar 2019

### **Responsible for Module:**

Bogenberger, Klaus; Prof. Dr.-Ing.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Urbane Seilbahnen (Vorlesung mit integrierten Übungen, 2 SWS)

Bogenberger K [L], Bogenberger K ( Glöckl U, Schönhofer T ), Glöckl U ( Schönhofer T )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### **BGU68005: ICT-Enabled Business Models for Urban Mobility | ICT-unterstützte Unternehmensmodelle für urbane Mobilität [Business Models for Urban Mobility]**

*ICT-Enabled Business Models for Urban Mobility*

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Written Term Paper that needs to be submitted at the end of the semester. Students will need to show that they understood the range of possible ICT-enabled business models and that they are able to apply these concepts to actual transportation planning problems.

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

Transport Planning Models (BV520010)

#### **Content:**

The module introduces students to old and emerging urban mobility services, stimulates ideas in the contemplation of new business models for the evolving urban mobility ecosystem, and furnishes students with the know-how needed to set up their own business. The module and group exercises cover the following topics:

- Evolution of Urban Mobility
- Information Technologies and Transportation
- Urban Mobility Services and Business Models
- Carsharing Models
- Transportation Network Companies vs. Taxis
- Issues Facing Shared Mobility Services (Safety and Security, Insurance, Labor and Employment)
- Integrated Mobility Platforms
- Starting a business in urban mobility (Factors to consider, Financing, Business Plan preparation)

**Intended Learning Outcomes:**

After completing this module, students will be able to

- Appreciate the different Urban Mobility Services, describe their differences and explain pros and cons.
- Understand the challenges of existing Urban Mobility Business Models
- Identify opportunities for Business in Urban Mobility
- Obtain the know-how to set up an Urban Mobility Business

**Teaching and Learning Methods:**

An interactive class with a combination of lectures and group exercises. The group exercises are presented and discussed in class to give students the opportunity to provide input and also learn from one another.

**Media:**

Presentations, discussions and group exercises in class

**Reading List:**

- Committee for Review of Innovative Urban Mobility Services (2016). TRB Special Report 319, Between Public and Private Mobility: Examining the Rise of Technology-Enabled Transportation. Transportation Research Board.
- Lerner, W., & Van Audenhove, F. J. (2012). The future of urban mobility: Towards networked, multimodal cities in 2050. Public Transport International-English Edition, 61(2), 14.
- Rodrigue, J. P., Comtois, C., & Slack, B. (2013). The geography of transport systems. Routledge.
- Armbruster, M. (2015). Start your business now: Your guide for success. Bayerischer Industrie- und Handelskammertag e.V. (BIHK).

**Responsible for Module:**

Moeckel, Rolf; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

ICT-Enabled Business Models for Urban Mobility

Matthew Okrah

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU68006: Road Safety | Straßenverkehrssicherheit [Road Safety]

#### Road Safety

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>90          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module is graded by a project work (Projektarbeit) including a final presentation.

The project work deals with road safety, selected in agreement with the students and the instructors. Students must clearly define the research question, the scope of the project and the methodology. Students must carry out a critical evaluation of the results.

The project work must include, at least, the following parts: 1. Literature review, 2. Problem definition, 3. Selection and description of the methodology, 4. Analysis of results and 5. Discussion and conclusions. The project work must apply the content of the module and use the appropriate technical language.

The grade consists of the written part of the project work (70%) and a final presentation (30%) of the project work. The recommended number of pages of the written part is 15-25 pages and the recommended duration of the final presentation is 15-20 min. Students have to work in small teams of 3 to 5 members and clearly define their individual contributions. The evaluation of the written part tests the ability of students to formulate problem statements in the area of road safety, to perform a comprehensive literature review of scientific literature, to design, describe and apply scientific methods and to analyze their results. With the presentation and its discussion, students additionally prove their ability to synthesize and communicate complex road safety problems using the appropriate technical language, and to carry out a scientific discussion about their results.

Examples projects of previous years include:

- Identify significant predictors of injury severity in cyclist crashes
- Determination of Severity of Accidents using Statistical Learning Methods
- An analysis of road traffic accidents in different weather conditions.

#### Repeat Examination:

End of Semester

**(Recommended) Prerequisites:**

None

**Content:**

The module covers the following topics:

- Crash causation factors and driver behavior.
- Statistical modelling of crashes.
- Alternative road safety measures.
- Vulnerable road users.
- Safety countermeasures in rural and urban roads.
- Tools for road safety management (Road Safety Inspection and Road Safety Audit).
- Road safety campaigns.
- Economic assessment.
- Connected and automated vehicles.
- Driving assistance systems.

**Intended Learning Outcomes:**

After completion of this module, students are able to:

- Describe road crash causation factors related with driver, vehicle and infrastructure.
- Explain the process and goals for road safety inspections and road safety audits.
- Implement economic assessments of road safety.
- Identify risks and measures for vulnerable road users.
- Identify safety issues at various types of road infrastructure.
- Conduct statistical analysis from road safety databases.
- Predict the road safety level of road facilities based on rigorous statistical techniques.
- Design safety countermeasures to address specific safety problems.

**Teaching and Learning Methods:**

The module consists of two lectures, one on introductory and one on advanced road safety concepts. Both classes are interactive and alternate lecture sessions with exercises (individual) and small projects (not graded, to be completed during the class and presented by small groups of students).

**Media:**

Slides for the presentations used in the class. Datasheets, plans or maps for the exercises and projects.

**Reading List:**

- Simon P. Washington. Statistical and econometric methods for transportation data analysis. CRC Press (2011).
- Hauer, Ezra. Art of Regression Modeling in Road Safety. Springer (2014).
- Additional journal and conference papers will be provided and examined in the class.

**Responsible for Module:**

Moeckel, Rolf; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Fortgeschrittene Straßenverkehrssicherheitskonzepte (Vorlesung, 3 SWS)

Antoniou C [L], Antoniou C, Moghavem Ghaffari S, Al Haddad C, Lu Q

Grundlagen der Verkehrssicherheit (Vorlesung, 3 SWS)

Llorca Garcia C [L], Llorca Garcia C, Moreno Chou A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU70006: Statistical Learning and Data Analytics for Transportation Systems | Statistisches Lernen und Datenanalyse für Verkehrssysteme** [Statistical Learning and Data Analytics for Transportation Systems]

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The coursework is evaluated based on 4 problem sets (Übungsleistung), aimed at assessing the students' achievement of the learning outcomes. This method of evaluation has been chosen based on the nature of the module (working with real data, and exploring the applicability of alternative analysis methods).

Each individual problem set/homework assignment will aim at demonstrating that the students have understood the concepts presented in a specific topical set of lectures. The students will use synthetic and real data to demonstrate that they have learned the presented material. The module uses the freely available R software, but the students will be allowed to complete the problem sets in other environments (e.g. matlab, python), if they prefer that. Each problem set will be graded individually and the final grade will be obtained as the weighted average of the individual grades (the weights will be determined based on the work-load associated with each problem set).

This module is also available to the participants of the TUM Skills Excellence Program. For the participants of this programme there are 20 places available.

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

linear algebra, applied statistics

**Content:**

The module provides the participants with an overview of the advanced methods that are available to perform statistical learning and big data analytics for transportation systems analysis. The following key areas will be covered:

- Visualization of high dimensional data
- Dimensionality reduction and data mining techniques
- Clustering and classification for high dimensional data
- Statistical Learning
- Going beyond (linear) regression
- The EM Algorithm
- Time series modeling and forecasting
- State space model and solution approaches, e.g. Kalman Filters

**Intended Learning Outcomes:**

After the completion of the module, the students will have established a solid theoretical foundation and knowledge base for statistical learning and data analytics. The aims of this module enable the students to:

- identify appropriate statistical learning and data analytics methods for a given transportation systems data set and research question;
- understand the ideas behind the methods, their purposes, their assumptions and their limitations;
- apply statistical learning and data analytics techniques using R (or another suitable software tool, e.g. matlab or python, if they so choose), and interpret the results;
- critically evaluate statistical learning and data analytics results from the literature.

**Teaching and Learning Methods:**

Format: Lecture with integrated practical exercises;

Lectures introduce the students to the concepts of statistical learning and data analytics using slide presentations, supported by whiteboard writing and discussions, and provide an overview of the available quantitative methods for statistical learning, big data analytics, and interpretation of the results. All methods and the calculation will be illustrated with real data sets, using open source statistical software. The given problems sets will be completed individually by each participant.

**Media:**

Presentation slides, whiteboard, readings

**Reading List:**

- Wolfgang Karl Härdle (2011) Applied Multivariate Statistical Analysis 3rd Ed.
- Brian Everitt, and Torsten Hothorn, (2011) An Introduction to Applied Multivariate Analysis with R. Springer
- Robert H. Shumway, David S. Stoffer, (2017) Time Series Analysis and Its Applications, 4th Ed. Springer

**Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Statistical Learning and Data Analytics for Transportation Systems (Vorlesung mit integrierten Übungen, 4 SWS)

Antoniou C [L], Antoniou C, Moghavem Ghaffari S, Lyu C, Mahajan V, Lu Q

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU70007: Special Topics on Model Calibration | Spezielle Themen zur Modellkalibrierung [Special Topics on Transportation Model Calibration]

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>30   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The expected learning outcome is verified in the form of a project work with an included presentation. The work is composed of 1 integrated project that each student undertakes individually, aimed at assessing the students' achievement of the learning outcomes.

The project is designed to enable the participants, to demonstrate their ability of applying the presented calibration concepts in several stages (15% data analysis and preparation, 10% development of the experimental design, 25% choice and implementation of the calibration algorithm, 15% integration in the simulation platform, 15% execution of the simulations, 20% capture and analysis of the results). This method of evaluation has been chosen based on the nature of the course (working with real data and software, and exploring the applicability of alternative analysis methods to achieve a well-defined goal). A final presentation will provide the opportunity to the students to organize their work, and receive more formal feedback, while the main deliverable will be the final report, which should be between 30 and 50 pages. The final grade will be determined as a weighted average of the presentation and final report in the following way: final presentation 25%, final report 75%.

This module is also available to the participants of the TUM Skills Excellence Program. For the participants of this programme there are 30 places available.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Traffic simulation and optimisation fundamentals are useful, but not strictly required; familiarity with scripting (e.g. in matlab/python) is a plus

### **Content:**

The content of the module aims to provide the participants with an overview of the core calibration and validation principles for transportation systems analysis, as well as a hands-on practical semester-long project that will allow them to apply what they learn to a real-world problem with state-of-the-art software. The following key areas will be covered:

- Development of an overall calibration and validation procedure
- Identification and selection of calibration and validation parameters
- Choice of suitable goodness-of-fit measures
- Data cleaning and quality assessment
- Sensitivity analysis
- Management of massive computational complexity
- Assessment, analysis and exploitation of calibration and validation outputs
- Visualization and systematic presentation of outputs and results

### **Intended Learning Outcomes:**

After the completion of the course, the student will be in a position to perform, assess and evaluate systematic calibration procedures for all types of simulation models. The aims of this course enable the students to:

- identify appropriate calibration and validation procedures for a given transportation systems data set and research question;
- understand the ideas behind the main calibration and validation methods, their purposes, their assumptions and their limitations;
- apply systematic calibration and validation methods using suitable software tools (e.g. interfaces based on matlab or python, as well as transport simulation software), and interpret the results;
- critically evaluate calibration and validation outputs and prepare outputs for use by different types of decision makers (engineers, managers, policy-makers)

### **Teaching and Learning Methods:**

Format: Project

Lectures introduce the students to the concepts of model calibration and validation using slide presentations, supported by whiteboard writing and discussions, and provide an overview of the available quantitative methods. Suitable software is introduced by the lecturers and provided to the students, along with all necessary data, in order to perform the required project work. The software comprises the traffic simulation software sumo, along with a matlab interface and python interfaces linking matlab and sumo. The students need to primarily interact with the software platform primarily through the matlab interface, through which they develop and execute the calibration algorithms. At the end of the project, the participants need to describe the algorithm that they implemented, document the process they followed in applying the experimental setup, summarize the simulation results that they obtained and comment on them (e.g. identify limitations, or aspects they could have improved). The lecturers work with the students during the remaining time, and the students also work individually between lectures. The project work will be completed individually by each participant.

**Media:**

Presentation slides, whiteboard, readings, software and data

**Reading List:**

Daamen, W., Buisson, C., & Hoogendoorn, S. P. (Eds.). (2014). Traffic Simulation and Data: Validation Methods and Applications. CRC Press.

Antoniou, C., J. Barcelo, M. Brackstone, H.B. Celikoglu, B. Ciuffo, V. Punzo, P. Sykes, T. Toledo, P. Vortisch and P. Wagner (2014), Traffic Simulation: Case for Guidelines, (M. Brackstone, V. Punzo, eds), JRC Scientific and Technical Research Report, EUR 26534 EN. Publications Office of the European Union, Luxembourg. ISBN 978-92-79-35578-3.

Antoniou, C., J. Barceló, M. Breen, M. Bullejos, J. Casas, E. Cipriani, B. Ciuffo, T. Djukic, S. Hoogendoorn, V. Marzano, L. Montero, M. Nigro, J. Perarnau, V. Punzo, T. Toledo and H. van Lint (2016). Towards a generic benchmarking platform for OD flows estimation/updating algorithms: design, demonstration and validation. Transportation Research Part C, 66, pp. 79-98.

**Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Special Topics on Model Calibration (Projekt, 2 SWS)

Antoniou C [L], Antoniou C, Rothfeld R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU70008: Urban Transportation Systems: Operations Research and Emerging Mobility Technologies | Urbane Verkehrssysteme: Betriebsforschung und neue Mobilitätstechnologien [Urban Transportation Systems]**

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The examination of the module consists of 2-3 problem sets on operations research and one take-home essay to be written for emerging mobility technologies.

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

Applied probability and statistics (e.g. BGU70009)

#### **Content:**

The module provides students with an overview of the advanced mathematical analytics for modeling operations of urban transportation systems. The module covers the following components:

- Probabilistic modeling (Poisson Processes, Geometric Probability, Perturbation, Crofton's Method)
- Queueing Theory and Its Applications (Birth-and-Death Process)
- Network Optimization Models (Shortest-Path, Maximum Flow, Minimum Cost, Facility Location)
- Linear Programming (Network Simplex Method)

Besides, this module provides its students with an overview of the effects of emerging forms of transportation, such as ride-hailing and Mobility-as-a-Service (MaaS). The literature on behaviour effects and traffic externalities is analysed in detail, and then the elements for the regulation of these technologies are discussed. The following key areas will be covered:

- The concept of sharing economy
- Ride-hailing: effects on travel behaviour and traffic externalities
- Ride-hailing and substitute modes: competition and increased efficiency
- Regulation of ride-hailing: pricing and optimal fleet size.
- Shared fleet optimal deployment and optimal routing.
- Mobility-as-a-service: bundling future transportation modes.
- Shared mobility and vehicle ownership: future scenarios and the role of the regulator.

### **Intended Learning Outcomes:**

After completion of the module, the students will understand the methodological and empirical basis for the analysis of emerging transportation technologies such that ride-hailing, shared ride-hailing and mobility as a service. The students will have established a solid theoretical foundation and knowledge base for modeling of urban transportation and service systems. Therefore, the students are able to:

- understand the mathematics behind urban operation research methods, their assumptions and limitations;
- apply modern techniques to formulate a mathematical operations research model and interpret the results;
- identify the main analytical models (e.g., optimization models) and econometric tools for the analysis of behaviour and traffic effects of such technologies.
- design an economic model for the regulation of ride-hailing and to solve it.
- discuss the latest research on merging transportation modes and identify the main elements that a regulation should have.

### **Teaching and Learning Methods:**

The module consists of lectures with integrated exercises.

Lectures introduce the students to the concepts of probabilistic analysis and modeling, queueing models, graph theory, and linear programming methods for modeling urban transport systems or network-wide optimization.

Besides, integrated practical exercises provide the students with the theoretical basics of the assessment of emerging modes, e.g. the various parts of appropriate optimization and econometric models presented in the literature. A social welfare maximization model for the regulation of ride-hailing will be solved in the lectures by the students with support from the lecturer, and applied to realistic scenarios using empirical values for input variables and attributes. State-of-the-art papers will be presented and discussed.

Along the course, lectures will use slide presentations, supported by whiteboard writing. Student discussion and active participation will be encouraged throughout the lectures. All methods and calculations will be illustrated with practical examples. Exercises will be given to students following each major topic, and the solutions will be presented and explained in the lectures.

The module will be shifted to the winter term, starting with winter semester 2022/23.

### **Media:**

The contents are provided with presentation slides, whiteboard, exercises, readings.

### **Reading List:**

- Circella, G., F. Alemi, K. Tiedeman, S. Handy and P. Mokhtarian (2018). The Adoption of Shared Mobility in California and Its Relationship with Other Components of Travel Behavior Report, National Center for Sustainable Transportation, United States.
- Docherty, I., G. Marsden and J. Anable (2018). The governance of smart mobility. Transportation Research Part A: Policy and Practice 115: 114-125.
- Hall, J. D., C. Palsson and J. Price (2018). Is Uber a substitute or complement for public transit? Journal of Urban Economics 108: 36-50.
- Henao, A. and W. E. Marshall (2018). The impact of ride-hailing on vehicle miles traveled. Transportation <https://doi.org/10.1007/s11116-018-9923-2>.
- Hillier, S. F., Lieberman, J. G. (2001) Introduction to operations research, 7th ed., McGraw-Hill
- Kamargianni, M. and M. Matyas (2017). The Business Ecosystem of Mobility-as-a-Service. 96th Transportation Research Board (TRB) Annual Meeting, 8-12 January 2017, Washington DC.
- Larson, R. and Odoni, A. (1981) Urban Operations Research, Prentice Hall, (available at: [http://web.mit.edu/urban\\_or\\_book/www/book/](http://web.mit.edu/urban_or_book/www/book/))
- Matyas, M. and M. Kamargianni (2018). The potential of mobility as a service bundles as a mobility management tool. Transportation.
- Rader, J. D. (2010) Deterministic Operations Research: Models and Methods in Linear Optimization. John Wiley and Sons
- Shaheen, S. (2018). Shared Mobility: The Potential of Ridehailing and Pooling. Three Revolutions. Island Press, Washington, DC: 55-76.
- Tirachini, A. and A. Gómez-Lobo (2018). Does ride-hailing increase or decrease vehicle kilometers traveled (VKT)? A simulation approach for Santiago de Chile. International Journal of Sustainable Transportation. Forthcoming.

### **Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Emerging Mobility Technologies (Vorlesung mit integrierten Übungen, 2 SWS)

Antoniou C [L], Abouelela M, Lu Q

Urban Operations Research for Transportation Systems (Vorlesung mit integrierten Übungen, 2 SWS)

Antoniou C [L], Antoniou C, Abouelela M, Sadrani M, Lu Q

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV340019: Road and Rail Design | Entwurf und Bemessung von Straßen und Eisenbahnen

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>90          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Current information in view of the limited presence due to the CoViD19 pandemic: If the general conditions (hygienic rules, distance rules, etc.) for a presence check are not available, the planned form of examination can be changed to [specify the alternatively planned form of examination or the electronic (remote) examination] according to §13a APSO. The decision on this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the responsible examination committee.

The examination should be a written examination (Closed Book, 120 min).

The written examination consists of several calculation tasks related to road and rail specific problems. In the examination students demonstrate the knowledge of road and rail superstructure loading and models used for safety analysis and design procedures. The ability is tested to analyse the behaviour of road and rail superstructure and to create solutions based on the modelling tools and knowledge taught by the module.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Kinematics and dynamics of driving BV 340007,  
Construction of Traffic Infrastructure BV 340008,  
Infrastructure design BV 340009

#### Content:

Rail traffic and temperature loading, modelling procedures and tools for analysis and design of rail superstructure, Track stability, constructive features and design of ballasted track systems, Design

and testing of substructures and components, Tracks for urban rail transport, green tracks, noise and vibration mitigation, maintenance management.

Road pavement loading, modelling procedures and tools for analysis and design of asphalt and concrete pavements, Environmental impacts, constructive features and design of road superstructure, noise mitigation, maintenance management.

**Intended Learning Outcomes:**

After completion of the module, students are able to understand the behaviour of road and rail superstructure loaded by rail traffic and additional loading (temperature), to apply procedures and modelling tools for superstructure design and to analyse constructive features. Students are able to create proposals for structural improvement of road and rail superstructure.

**Teaching and Learning Methods:**

The module is based on conventional lectures with integrated exercises, supported by Powerpoint presentation. Demonstration materials are used to support the description of topics, videos are part of the presentation. The content of the lectures is practised by exercises during the lectures. An excursion takes place to study the practical transfer and implementation of lecture content

**Media:**

Lecture notes, handouts, Powerpoint presentations, board work, videos, excursion

**Reading List:**

Lecture notes

Bernhard Lichtberger, Track Compendium; Eurailpress; ISBN 3-7771-0320-9

Coenraad Esveldt; Modern railway track; MRT Productions; ISBN 90-800324-3-3

T.F.Fwa; The Handbook of Highway Engineering; Taylor and Francis ISBN 978-0-8493-1986-0

**Responsible for Module:**

Stephan Freudenstein (stephan.freudenstein@tum.de) Bernhard Lechner  
(bernhard.lechner@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Road Design (Vorlesung mit integrierten Übungen, 3 SWS)

Lechner B [L], Lechner B, Simon C

Rail Design (Vorlesung mit integrierten Übungen, 3 SWS)

Lechner B [L], Lechner B, Stahl W, Freudenstein S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### **BV520009: Project Appraisal and Planning Processes in Transportation | Projektbewertung und Planungsprozesse im Verkehr**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105  | <b>Contact Hours:</b><br>75          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination consists of a 120-minute written exam. In the written exam students demonstrate without helping material and under time pressure that they have understood concepts of transport economy and of economic assessment methods and can depict those aspects in a compacted form. Furthermore they illustrate solutions for different application scenarios. Additionally they demonstrate their ability to explain the basics of planning procedures, the transport policy and its impact, costs and financing as well as realization and evaluation of projects.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

-

#### **Content:**

This module deals with planning processes and project appraisal in transportation. First, the basic principles and concepts of transport economy and system assessment will be introduced. The emphasis is set on environmental and economic assessment tools regarding transportation. Students learn theories and methods to evaluate the environmental impacts in matters to transportation. Basic concepts are applied to actual examples. Moreover, economic assessment methods like the Cost-Benefit-Analysis (CBA) or Multi-Criteria-Analysis (MCA) as well as corresponding applications are introduced and constraints of specific assessment procedures are discussed. Furthermore, concepts of travel demand, costs and technology will be presented and discussed within the context of transport economics.

Besides, this module deals with strategic planning on international/national as well as local/regional level. Further topics are

project development and approval, feasibility studies and environmental assessment. Students will also learn about financing and realisation of transportation projects as well as regional governance participation.

### **Intended Learning Outcomes:**

At the end of the module students are able to analyze and interpret the multi-level connection of environmental and economic aspects of transportation. For example, from the economic point of view students are able to identify an appropriate assessment method and to apply it correctly. Furthermore, they understand the relevant steps of a planning process. The students are also able to define important terms within the area of transport economy and economic assessment methods.

Moreover the students are able to

- identify the formal and informal planning instruments, participation procedures, feasibility studies, costs and financing of transportation projects, their realization and evaluation in Germany and Europe;
- apply the theories and basics of planning and transportations policies;
- apply basic elements of planning to many different contexts;
- identify the main factors influencing planning policies and design mobility concepts.

### **Teaching and Learning Methods:**

The module consists of two lectures and an exercise. During the lectures the content is provided via presentations, PowerPoint slides and interactive discussions. Practical examples including calculations illustrate the theoretical basics. Group work and exercises allow the deeper understanding using additional examples. The students are inspired to improve the acquired knowledge by studying the suggested literature.

### **Media:**

Presentation (handouts), multimedia online tools

### **Reading List:**

Blauwens, G.; De Baere, P.; Van de Voorde, E. [2008]: Transport Economics. Third Edition. De Boeck, Antwerpen.

Haezendonck, E. [2007]: Transport Project Evaluation - Extending the Social Cost-Benefit Approach. Edward Elgar, Cheltenham, Northampton.

Varian, H. R. [2006]: Intermediate Microeconomics - A Modern Approach. Seventh Edition. W. W. Norton & Company, New York, London.

Edwards-Jones, G.; Davies, B.; Hussain, S. [2000]: Ecological Economics - An Introduction. Blackwell Science, Oxford.

### **Responsible for Module:**

Bogenberger, Klaus; Prof. Dr.-Ing.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Transport Economy and System Assessment (Exercise) (Übung, 1 SWS)

Bogenberger K [L], Spangler M ( Fehn F, Hamm L, Weigl S )

Transport Economy and System Assessment (Lecture) (Vorlesung, 2 SWS)

Bogenberger K [L], Spangler M ( Fehn F, Hamm L, Weigl S )

Transportation Policies and Project Design (Vorlesung, 2 SWS)

Wulfhorst G, Duran Rodas D, Horlemann J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### ED150005: Modelling Tools and Practice Insight for Traffic Engineering | Modellwerkzeuge und Einblick in die Praxis des Verkehrsingenieurwesens [MTPI]

Version of module description: Gültig ab summerterm 2022

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>90          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a written project report of ca. 30 pages. The module contains a series of mandatory excursions.

In the course of the module, students receive a practice oriented project that requires both microscopic and macroscopic approaches. Through this examination form, they prove their ability to compose engineering reports on their work to the requirements of realistic transport planning tasks. Through the methodological part of the report, they prove their ability to choose the appropriate model for their assigned task, develop, calibrate and validate their simulation networks to the requirements of the task and apply different simulation models for private and public transport. Through the result part of the report, they prove that they are able to analyse different scenarios of transport related measures, evaluate the quality of planned measures using the model results and design new measures – always with a critical view on the quality of the model results. Through the discussion part of the report, they prove their ability to deliver qualified recommendations for engineering problems using simulation results and that they can contribute to decision making processes in transport planning practice. The participation on at least half of the ca. eight mandatory excursions ensures that the students know the requirements of their future employers on their ability to work and apply modelling approaches on engineering projects.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Knowledge in Traffic Flow Theory (e.g. BV560024 Traffic Management)

Knowledge in Urban Traffic Control (e.g. BV560024 Traffic Management)

Knowledge in Transportation Planning for private and public transport

Students need a laptop for the seminar sessions

### **Content:**

The module is taught in a project oriented way, provides however regular methodological and technical input.

Introduction phase:

- introduction into the project task for the semester
- introduction in microscopic and macroscopic modelling and evaluation of transportation related measures
- first steps with the software VISSIM and VISUM

Technical Input:

- Elements of a microscopic traffic simulation (network, vehicle types, ...)
- Design of a unimodal traffic network
- Static and dynamic traffic assignment
- Multi-modal network (public transport, bicycle, pedestrian, ...)
- Basic functions of traffic control (e.g. signal control)
- Model calibration and validation
- Interfacing Macroscopic and microscopic models

Project phase:

- Structuring of a model-based engineering project
- Requirements on engineering reports
- Use of models and model results in reporting and decision making processes

Excursions:

- visits to planning companies, industry companies and public authorities

### **Intended Learning Outcomes:**

At the end of the module, students are able to:

- understand the concepts of microscopic traffic flow simulation
- understand the concepts of macroscopic transport simulation
- build networks in microscopic and macroscopic simulation
- introduce traffic control in microscopic simulation networks
- calibrate and validate simple microscopic simulations
- Evaluate simulation scenarios
- critically analyse the simulation results
- Use simulation results to assist decision making processes
- Compose engineering reports on realistic planning tasks
- know the scope of employers for transportation and traffic engineering
- link their modelling abilities to the requirements of possible employers

### **Teaching and Learning Methods:**

The teaching form is a seminar. Students receive at the beginning of the semester a project task that they should work on during the semester utilising upon their own experience with transport planning and supported by modelling software. Methodological and technical input is given in interactive teaching sessions. Lecturers provide insight into the specific steps of the project and

guide the students in the use of the modelling software. During the sessions students can test their skills on short practical tasks. The students are introduced to work on large, practical tasks in the seminar. In further input sessions they are introduced on the requirements of engineering reports and the use of modelling results in those reports. For the most part, the students work on their project independently and exchange ideas with the supervisors during the classroom sessions. Excursions to visit institutions that constitute possible employers for the graduates help to link the practical simulation work with the requirements of transportation engineering practice. The project report can be written either in English or in German language.

**Media:**

Power point presentation, teaching videos, software on own computer, excursions

**Reading List:**

User's manual of the software VISUM and VISSIM

**Responsible for Module:**

Dipl.-Phys. (Univ.) Florian Dandl: [florian.dandl@tum.de](mailto:florian.dandl@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Verkehrsflusssimulation-Grundlagen (Seminar, 3 SWS)

Bogenberger K [L], Bogenberger K ( Amini S, Dandl F ), Dandl F ( Amini S )

Praxis der Verkehrstechnik und Verkehrsplanung (Vorlesung, 1 SWS)

Bogenberger K [L], Dandl F ( Tsakareostos A ), Glöckl U ( Dumler K )

Projekt in Makroskopischer Verkehrssimulation (Seminar, 2 SWS)

Bogenberger K [L], Dumler K ( Tsakareostos A ), Spangler M ( Tsakareostos A ), Tsakareostos A ( Dumler K )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Field of Study 11: Water-Energy-Food Nexus | Vertiefung 11: Water-Energy-Food Nexus

### Required Modules | Pflichtmodule

#### Module Description

### BGU38038: Urban Water-Energy-Food Nexus | Urban Water-Energy-Food Nexus [WEF Nexus]

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The proof of performance will be made in the form of a project. This project will be conducted in small groups of 6-8 students, whereby an individual thematic focus will be defined for each student. It consists of a group report (70%, 3-5 pages per student) and interim and final presentations (30%, ca. 5 min per student) where individual contributions will counts for 60% and group interaction for 40% of the grade. The aim of the project is to prove understanding of basics of different technical and non-technical components of integrated urban planning and their application in the development of simple urban planning projects. The project requires an intensive analysis of the thematic focus and thus the students prove an in-depth understanding of these components and the ability to combine these in an innovative way. This understanding will be proven using planning, geographic information systems-based, calculatory and modeling methods. At the end of the course, the students prove their ability to present and explain their concepts, approaches and methods in front of an expert audience through a presentation and a short discussion. Further, students proves their ability to work scientifically on their individual content through submission of the individual parts of the report.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering (BGU38014)

**Content:**

This module deals with concepts, approaches and methods for integrated urban planning. Good practice examples are discussed in general terms before learning to apply these to a concrete case study city. In addition, students will learn about concepts and driving forces of the topics urbanization, globalization, climate change, environmental challenges, sustainability including UN Sustainable Development Goals (SDGs) as well as current research on water reclamation with resource recovery.

**Intended Learning Outcomes:**

Upon successful completion of this module, students are able

- To know and explain contextual challenges and existing concepts, approaches and methods to address these
- To understand and explain international development dynamics and implications for natural resources consumption patterns
- To choose and compare technical and non-technical components of integrated urban planning
- To evaluate technical and non-technical components of integrated urban planning in terms of their context
- To develop innovative concepts and combinations of these components
- To communicate in an interdisciplinary group and collaborate on joint results
- To present own results in a scientific manner in presentations and a report

**Teaching and Learning Methods:**

The module will be taught as a combination of a lecture series and a project. Major content will be explained in form of lectures with integrated discussion. In the project, students will work with the guidance of the tutor to develop solutions for selected case studies. Following an introduction into the project, they will work in groups, where every student will work on individual aspects of the project. Results will be presented in a joint group report and a final presentation.

**Media:**

Presentations, group work

**Reading List:**

1. Hoff, H. (2011). Understanding the Nexus. Background Paper for the Bonn2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm, pp. 52.
2. Gondhalekar, D. and T. Ramsauer (2017). Nexus City: operationalizing the urban Water-Energy-Food Nexus for climate change adaptation in Munich, Germany. Urban Climate 19: 28–40, DOI: 10.1016/j.uclim.2016.11.004 [OA]

**Responsible for Module:**

Keilmann-Gondhalekar, Daphne (d.gondhalekar@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Urban Water-Energy-Food Nexus Planung (Vorlesung, 2 SWS)  
Keilmann-Gondhalekar D [L], Keilmann-Gondhalekar D



Urban Water-Energy-Food Nexus Projekt (Projekt, 2 SWS)

Keilmann-Gondhalekar D [L], Keilmann-Gondhalekar D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46038: Principles and Applications of Land Management | Prinzipien und Anwendung von Landschaftsmanagement

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment is based on a written exam of 90 minutes with open questions. Such open question test to which extent students can individually formulate feasible and plausible answers in their own words in relation to descriptions, explanations and analysis of basic conceptualisations of land management and landscape management. In addition, the open question should test to which extent students are able to formulate judgements and appropriate solutions for land management challenges and formulate appropriate research questions in relation to land management themes. During the exam only a hardcopy dictionary and a calculator are allowed.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic understanding of of law and environmental systems.

#### Content:

This module will provide foundational knowledge for sustainable land management in both rural and urban areas by a combination of two complementary approaches: land administration and landscape planning.

Land administration comprises of 4 fundamental components: cadastral land surveying, land registration, land valuation and land development. These components together rely on a land information infrastructure and provide the basis for systematic and comprehensive land interventions.

The module will address the guiding principles, formal instruments and procedural elements of Landscape Planning; present methodological approaches for the assessment of natural assets and landscape functions including methods and tools for data collection, analysis and evaluation; illustrate target formulation and implementation strategies with examples from the planning practice.

### **Intended Learning Outcomes:**

On successful completion of the module, participants should:

1. recognize, describe and explain core concepts and principles of responsible and smart land management, land administration and landscape management.
2. explain and apply basic tools, instruments and procedural elements of land administration (including cadastral mapping and land registration) and landscape management.
3. select appropriate methods and tools to design assess natural assets and landscape functions.
4. judge and assess the role and application of land management tools and instruments in the context of sustainable development challenges and requirements.
5. be able to transfer principles and apply tools of land management to secure land tenure, develop and plan urban and rural regions in a responsible and sustainable manner.

### **Teaching and Learning Methods:**

This module relies on active learning methods. The required background knowledge on each of the topics is introduced via both verbal/frontal lectures and via open access background papers and articles (which students have to read and comprehend during and via self study hours). Students are required to apply this knowledge either individually and/or in groups in exercises. The exercises are structured such that students have to combine different sources in order to derive and formulate feasible answers and/or solutions. The exercises are based on actual cases in both Germany and abroad. These seminar type exercises aim to transfer this knowledge for developing a tenure responsive and/or ecologically sustainable strategy at the neighbourhood and/or a national scale. Through these exercises the application of knowledge is practiced. For the exam these knowledge application experiences are required.

### **Media:**

Lectures provide subject specific knowledge; class discussions of selected readings engage students in critical thinking.

### **Reading List:**

Haaren, Chr. v., Galler, C. & S. Ott (2008): Landscape planning. The basis of sustainable landscape development. Ed. by Federal Agency for Nature Conservation; Further thematic reading will be made available in connection with the lectures and the seminar

**Responsible for Module:**

Prof. Walter Timo de Vries wt.de-vries@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Integrated Land and Water Management (Vorlesung, 4 SWS)

de Vries W, Disse M, Pauleit S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Elective Modules | Wahlmodule

### Module Description

## WZ2720: Renewable Energy Technologies | Renewable Energy Technologies

Version of module description: Gültig ab winterterm 2015/16

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

### Description of Examination Method:

The examination consists of a written test, where the students have to proof that they understand and remember the basic technical principles related to energy production and the working principles of the presented renewable energy technologies, as well as the related ecological and economical properties and frame conditions. The students have to answer questions, but may also be asked to do calculations, complete figures or prepare sketches.

### Repeat Examination:

Next semester

### (Recommended) Prerequisites:

General understanding of natural science, mathematics and basics of technology.

### Content:

The course provides an overview of the basics of thermodynamics and the principles of energy conversion. Energy conversion and its importance for the economy is discussed. Because of their transitional character due to the German "Energiewende", the course focusses on the European and German energy systems. The international students in the course are expected to support the lecture with their experiences from abroad.

Basic technical principles of energy production, efficiencies, costs and environmental impacts will be understood. The focus lies on the following areas: solar, wind, water and geothermal energy conversion.

The course provides an overview of the basics of thermodynamics and the principles of energy conversion. Energy conversion and its importance for the economy is discussed. Because of their transitional character due to the German "Energiewende", the course focusses on the European

and German energy systems. The international students in the course are expected to support the lecture with their experiences from abroad.

Basic technical principles of energy production, efficiencies, costs and environmental impacts will be understood. The focus lies on the following areas: solar, wind, water and geothermal energy conversion.

In order to complete the picture, also storage and fossil fuel technologies will be discussed. The students will understand their role and their contribution to balancing energy production and demand.

**Intended Learning Outcomes:**

At the end of the course, the students understand the technical principles of renewable energy conversion systems.

They are able to interpret energy scenarios and solve simple problems associated with a high renewable energy share and its implications on society.

The students can estimate the importance of distinct technologies for a sustainable energy supply.

**Teaching and Learning Methods:**

Lecture with integrated exercises and teamwork, as well as discussions to improve understanding.

**Media:**

Power point presentation, black board, Videoclips

**Reading List:**

Tba

**Responsible for Module:**

Dr. Doris Schieder - Lehrstuhl für Chemie Biogener Rohstoffe [doris.schieder@tum.de](mailto:doris.schieder@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Renewable Energy Technologies (Vorlesung, 4 SWS)

Wieland C [L], Wieland C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ1065: Climate Change and Agriculture | Klimawandel und Landwirtschaft

Version of module description: Gültig ab winterterm 2021/22

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150         | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Prüfungsleistung wird in Form einer Präsentation erbracht, die durch einen Bericht ergänzt wird. Zum Semesterbeginn wird eine Liste an Themen vorgestellt, aus denen sich jeder Studierende sein individuelles Thema für die Präsentationsleistung aussucht.

Jedes Thema umfasst einen spezialisierten Anwendungsfall. Die Studierenden weisen darin nach, dass sie diesen hinsichtlich der Themen aus der Ringvorlesung (Klimatologie, Pflanzen-/Tierproduktion, Ökonomie, Maßnahmen) analysieren und bewerten sowie im Kontext agrarischer Produktionssysteme diskutieren können. Der Bericht muss einen Umfang von 5-10 Seiten aufweisen. Die Präsentation ist mit 15 Minuten Vortrag + 10 Minuten Diskussion angesetzt. Der Bericht sowie die Präsentation gehen beide mit 50% in die finale Notenbildung ein.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Grundlagen der Agrarwissenschaften

#### Content:

Die Modulveranstaltung orientiert sich an der Struktur des Intergovernmental Panel on Climate Change (IPCC).

Das IPCC erarbeitet als ‚Weltklimarat‘ für politische Entscheidungsträger den Stand der wissenschaftlichen Forschung hinsichtlich des Klimawandels, erstellt Prognosen über die Auswirkungen und zeigt Möglichkeiten zur Bekämpfung der globalen Erwärmung auf.

Das Modul folgt dabei den drei Arbeitsgruppen des IPCC und lädt zu jedem Themenbereich Gastvortragende ein.

Diese kommen aus verschiedenen Forschungsgruppen der TUM, der Ludwig-Maximilians-Universität sowie aus der Wirtschaft und Politik.

Der Hauptfokus liegt auf den Auswirkungen auf die landwirtschaftliche Produktion und Ökologie.  
Der Aufbau des Modules ist:

1. Naturwissenschaftliche Aspekte des Klimawandels:

- u.a. wodurch entsteht die globale Erwärmung, wie hängen Klima und Wetter zusammen, welche Daten lassen sich messen

2. Auswirkungen des Klimawandels:

- Effekte auf die Pflanzenproduktion, Adaption durch Pflanzenzüchtung, Modellierung von Zukunftsszenarien, Emission- und Reduktion durch die Tierhaltung, Risikokalkulation in der Ökonomie.

3. Möglichkeiten zur Minderung des Klimawandels

- Abschwächung des Klimawandels in Entwicklungsländern, Negative Emissionen zur Reduktion der Treibhausgase, Standpunkte der Politik sowie von Landwirtschaftsvertretern.

**Intended Learning Outcomes:**

Nach der Teilnahme an der Modulveranstaltung sind die Studierenden in der Lage:

- Die physikalischen Grundlagen des Klimawandels darzustellen
- Auswirkungen des Klimawandels auf die Pflanzen- und Tierproduktion sowie natürliche ökologische Systeme auf regionaler sowie globaler Ebene zu analysieren
- Ökonomische Konsequenzen der globalen Erwärmung zu beurteilen
- Maßnahmen zur Adaption und Abschwächung des Klimawandels zu bewerten.

Des Weiteren hat sich jeder Studierende intensiv mit einem individuellen Thema befasst und kennt in diesem Bereich den aktuellen Stand der wissenschaftlichen Forschung und kann diesen in Kontext mit agrarischen Produktionssystemen diskutieren.

**Teaching and Learning Methods:**

Die Vorlesung findet als Ringvorlesung statt, die sich thematisch an den Themen des für den Forschungsberichtes des Intergovernmental Panel on Climate Change (IPCC) orientiert und den Studierenden einen umfassenden Überblick über den aktuellen Forschungsstand in der agrarbezogenen Klimaforschung liefert.

**Media:**

Vorträge, Präsentationen

**Reading List:**

Handzettel zur Unterstützung der Präsentationen, Fallbeschreibungen

**Responsible for Module:**

Asseng, Senthold; Prof. Prof. Dr. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Klimawandel und Landwirtschaft (Vorlesung, 4 SWS)

Asseng S [L], Asseng S, Benjamin E, Herz M, Hoheneder F, Hülsbergen K, Maier H, Mennig P, Menzel A, Paulicks B, Priesack E, Schäfer H, Seitz F, von Bloh M, Wiesmeier M, Yildirim S



For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU36010: Energy-Building-City | Energie-Gebäude-Stadt

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Duration of examination: 90 min.

The aim of the written examination is to prove that complex building physics of energy, building and city related effects have been understood, can be condensed and applied, in particular dynamic heat transport and energy balances. In order to do this, problems must be detected and solved in a limited time and only with the help of a simple pocket calculator and given formulas. The examination questions cover the entire lecture material. The answers require partly own formulations, partly multiple-choice answers, and in addition to that calculations. No media are allowed except for a simple calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamental knowledge in building physics (heat, moisture, light, acoustics)  
engineering mathematics

#### Content:

The module deals with the fundamentals of dynamic thermal processes, in particular the dynamic one-, two- and three-dimensional heat transfer. These methods are applied to buildings and cities. Related energy balances will be explained. Specific phenomena ranging from small buildings to entire cities are depicted.

#### Intended Learning Outcomes:

Upon completion of the module, students will be able to quantitatively determine and evaluate complex building physics phenomena in the field of Energy-Building-City, as well as to characterize the related interrelations.

In addition, they are also able to independently develop adequate solutions for the typical building physics tasks in the areas of heat, humidity and energy. They can also abstract the building physics phenomena to other climatic regions.

After participating in the module, the students will understand more detailed principles of building physics methods of thermodynamics. They can analyze the associated processes at building level and at city level and can develop concepts and technology applications to influence them in the long term.

### **Teaching and Learning Methods:**

The module consists of lectures and exercises. The competencies in the areas of energy of components, buildings and cities are taught in the form of lectures through presentations. In the associated exercises, the topics taught (energy aspects of components, buildings and cities) are deepened by means of short repetitions and calculation exercises on theoretical problems and on application problems. In the context of the exercises for all parts, text tasks supplemented with sketches and diagrams are precalculated, which are also summarized in task sheets.

### **Media:**

Powerpoint presentations, blackboard work, films

### **Reading List:**

Gösele, Schüle, Künzel: Schall, Wärme, Feuchte. Bauverlag Wiesbaden, 10. völlig neu bearbeitete Auflage (1997).

Lutz, Jenisch, Klopfer, Freymuth, Krampf: Lehrbuch der Bauphysik - Schall, Wärme, Feuchte, Licht, Brand - B.G. Teubner, Stuttgart (1997).

Richter, Fischer, Jenisch, Freymuth, Stohrer, Häupl, Homann: Lehrbuch der Bauphysik - Schall - Wärme - Feuchte - Licht - Brand - Klima - Vieweg+Teubner, Wiesbaden (2008).

Bauphysik-Kalender 2001. Hrsg. E. Cziesielski. Ernst & Sohn Verlag Berlin (2001).

Sälzer, E.: Schallschutz im Massivbau. Bauverlag Wiesbaden (1990).

Zürcher, Ch.: Bauphysik. Verlag der Fachvereine Zürich, (1988).

Hauser, G., Stiegel, H.: Wärmebrücken-Atlas für den Mauerwerksbau. Bauverlag Wiesbaden, 3. durchgesehene Auflage (1996).

### **Responsible for Module:**

Prof. Klaus Sedlbauer

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Energie - Gebäude - Stadt (Vorlesung, 4 SWS)

Göttig R

Bauphysik Vertiefung 2 Gebäude/Stadtteil- Übung (Übung, 1 SWS)

Göttig R [L], Gocht S

Bauphysik Vertiefung 2 Gebäude/Stadtteil- Vorlesung (Vorlesung, 3 SWS)

Sedlbauer K [L], Sedlbauer K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38019: Anaerobic Processes and Energy Recovery | Anaerobtechnik und Energierückgewinnung

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The proof of performance is made in the form of a 60-minute written exam with questions on the fundamental understanding as well as small calculation tasks.

The aim of the written exam is the proof that the basic approaches in the field of energy recovery from urban waste streams were understood and different methods can be applied comparatively. Problems need to be analyzed and based on learning outcomes acquired in the course, students have to find and implement solutions in limited time. In the theoretical part, comprehension questions must be answered to basics of anaerobic technology and energy recovery from waste streams. In the calculating part, diverse issues should be analyzed and calculated based on the learning outcomes acquired during the module.

The answers require partly own formulations, partly ticking given single or multiple answers. The focus is on short calculation tasks. For the exam no aids are permitted except for a non-programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering (BGU38014)

#### Content:

- Basics of anaerobic digestion
- Co-digestion
- Power to gas
- Treatment of sewage sludge
  - o Agricultural use and incineration
  - o Recovery of phosphorous

**Intended Learning Outcomes:**

After the successful participation in the course, the students will be able to:

- remember the basic process concepts,
- analyze and evaluate the advantages and disadvantages of the different methods for the specific application,
- and develop simple approaches to calculate and dimension treatment schemes.

**Teaching and Learning Methods:**

The contents of the lecture are taught through practical examples. By means of example tasks in the lecture, possible solutions are discussed and exemplified calculations are performed. During exercise included in the lecture, students apply what they have learned on similar tasks and internalize the approach. The self-study is supported by the provision of further literature in Moodle.

**Media:**

Beamer, black board, literature provided

**Reading List:**

Appels, L., Baeyens, J., Degreè, J., Dewil, R., 2008. Principles and potential of the anaerobic digestion of waste-activated sludge. *Prog. Energy Combust. Sci.* 34, 755–781.

Chen, Y., Cheng, J.J., Creamer, K.S., 2008. Inhibition of anaerobic digestion process: A review. *Bioresour. Technol.* 99, 4044–4064.

Kelessidis, A., Stasinakis, A.S., 2012. Comparative study of the methods used for treatment and final disposal of sewage sludge in European countries. *Waste Manag.* 32, 1186–1195.

Roskosch, A., Otto, S., 2014. Technical Guide on the Treatment and Recycling Techniques for Sludge from Municipal Wastewater Treatment with references to Best Available Techniques (BAT). Fed. Environ. Agency Ger.

Wiechmann, B., Dienemann, C., Kabbe, C., Brandt, S., Vogel, I., Roskosch, A., 2013. Sewage sludge management in Germany. Umweltbundesamt, Bonn.

**Responsible for Module:**

Dr.-Ing. Konrad Koch, k.koch@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Anaerobtechnik und Energierückgewinnung (Vorlesung, 2 SWS)

Koch K [L], Koch K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU40035: Environment and Land Use Planning | Umwelt- und Landnutzungsplanung

Version of module description: Gültig ab summerterm 2020

|                                  |                            |                                  |                                      |
|----------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6            | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulleistung wird in einer schriftlichen Prüfung in Form einer Klausur erbracht. Ohne Hilfsmittel sollen die Studierenden Instrumente und Planungsprozesse der Umweltplanung wiedergeben und in eigenen Formulierungen die komplexen Zusammenhänge zwischen Umweltplanung und Bodenpolitik beim nachhaltigen Umgang mit Grund und Boden erläutern. Instrumente und Prozesse sollen in Fragen zu nationalen und internationalen Beispielfällen angewandt und auf ihre Wirksamkeit hin bewertet werden können. Die Studierenden sollen in eigenen Formulierungen Hintergründe, Aufgaben und Ziele nachhaltiger Landnutzungsplanung wiedergeben und die komplexen ökonomischen, ökologischen und eigentumsrechtlichen Zusammenhänge bei der Planung und Gestaltung von Landnutzung erläutern können. Beide Teilleistungen gehen zu gleichen Teilen in die Gesamtnote ein.

Aktueller Hinweis angesichts des eingeschränkten Präsenzbetriebs auf Grund der CoViD19-Pandemie: Sofern die Rahmenbedingungen (Hygiene-, Abstandsregeln etc.) für eine Präsenzprüfung nicht vorliegen, kann gemäß §13a APSO die geplante Prüfungsform auf eine online-gestützte schriftliche oder mündliche Fernprüfung umgestellt werden. Die Entscheidung über diesen Wechsel wird möglichst zeitnah, spätestens jedoch 14 Tage vor dem Prüfungstermin durch die Prüfungsperson nach Abstimmung mit dem zuständigen Prüfungsausschuss bekannt gegeben.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Modul Räumliche Planung und Verwaltungsrecht BGU 40032
- Modul Landmanagement für Geographen BGU 40033
- Modul Bodenordnung und Grundstückswertermittlung BGU 40034

-- Modul Kommunal und Landentwicklung BV 400006

**Content:**

Umweltplanung und Bodenpolitik

A) Grundlagen, internationale Zusammenhänge

- Begriffsdefinitionen
- Government und Governance
- Situation and challenges of land tenure and land policy in developing countries
- Sustainable Development Goals und der Aspekt Boden

B) Umweltplanung und Bodenpolitik in der Praxis in Deutschland

- strukturschwache Regionen, Integriertes Ländliches Entwicklungskonzept (ILE), Gemeindeentwicklung
- Stadtumbau, Soziale Stadt, Kompakt Urban Grün
- Verringerung des Flächenverbrauchs
- Konzepte zur Mehrfachnutzung von Land
- Erneuerbare Energien im ländlichen Raum – Chancen und Risiken
- Hochwasserschutz

Landnutzungsplanung:

- Landschaften in Mitteleuropa und die Art und Weise ihrer Nutzung
- nachhaltige Formen der Landnutzung und langfristige Sicherung der Ökosystemdienstleistungen von Landschaft
- Hintergründe, Aufgaben und Leitgedanken der Landnutzungsplanung in folgenden Kapiteln:
  1. Landschaftsplanung oder Landnutzungsplanung?
  2. Geschichte der Landnutzung in Mitteleuropa und ihre ökologische Auswirkungen
  3. Ökologische Grundlagen der Landnutzungsplanung
  4. Bausteine der Landnutzungsplanung
    - a. Stoff- und Energiestrommanagement
    - b. Projektentwicklung und Kommunikationsmanagement
    - c. Ökonomische Strategien
  5. Landnutzung mit unternehmerischen Menschen gestalten

**Intended Learning Outcomes:**

Nach der Teilnahme an der Modulveranstaltung kennen die Studierenden Instrumente und Prozesse der Umweltplanung und deren unterschiedliche nationale und internationale Einsatzfelder. Sie verstehen die aktuellen weltweiten Herausforderungen im Umgang mit Grund und Boden, erfassen den Zusammenhang zwischen Bodenpolitik und Umweltplanung und sind in der Lage, die Vor- und Nachteile bestimmter Planungsmethoden zu bewerten.

Sie kennen die ökonomischen und ökologischen Anforderungen an die Landnutzungsplanung, deren Aufgaben und Leitgedanken. Sie begreifen die Bedeutung nachhaltiger Formen der Landnutzung auf dem Hintergrund von Klimawandel, Flächenverbrauch, Sicherung der weltweiten Ernährung und Erzeugung von Energie und können die komplexen Zusammenhänge auch auf dem Hintergrund der Eigentumsstrukturen diskutieren.



**Teaching and Learning Methods:**

Lehrformat: Vorlesung

Methoden: interaktiver Vortrag mit Präsentation zur Vermittlung von Wissen. Die Lehrmethoden sind auf die Lernaktivitäten Materialrecherche, Studium von Literatur und Auswendiglernen ausgerichtet.

Gastdozenten vermitteln den Studierenden Einblick in die praktischen Einsatzfelder und Spezialwissen über die Wirksamkeit der Instrumente.

**Media:**

- Power Point Präsentation
- Vorlesungsskript

**Reading List:**

**Responsible for Module:**

Florian Siegert, [florian.siegert@tum.de](mailto:florian.siegert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Landnutzungsplanung (Vorlesung, 2 SWS)

de Vries W [L], Henger E ( Bendzko T )

Umweltplanung und Bodenpolitik (Vorlesung, 2 SWS)

de Vries W [L], Jacobsen C ( Hölzel M )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU40057: Decision Support Systems | Entscheidungsunterstützungssysteme [DSS]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consist of a written exam of 60 minutes (only dictionary allowed as aiding material). The written exam gives the proof that the student can select theories to assess and describe a given decision support problem and can apply relevant methods and tools to prepare and execute a decision support issue.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

None

#### Content:

The module covers the following topics:

- Definitions, goals and objectives of decision support systems
- Describing and categorizing a decision-making process
- Types of spatial decision support systems, and usage of decision support systems tools in the decision-making process?
- Principles of multicriteria analysis
- Spatial multicriteria analysis
- Cases of decision support systems in land management

#### Intended Learning Outcomes:

Upon completion of the module, students are able to:

- explain the principles of decision-making processes and decision support systems
- distinguish between various phases of the decision-making process and their required types of information relevant for land management

- discuss the linkages between GIS and decision support systems
- apply spatial multicriteria decision analysis techniques relevant for land management and compare different multicriteria evaluation techniques
- use spatial multicriteria evaluation techniques in proposing an appropriate solution to a spatial problem
- assess and interpret the results of the multicriteria evaluation process.

### **Teaching and Learning Methods:**

The module covers the following topics:

- Definitions, goals and objectives of decision support systems
- Describing and categorizing a decision-making process
- Types of spatial decision support systems, and usage of decision support systems tools in the decision-making process?
- Principles of multicriteria analysis
- Spatial multicriteria analysis
- Cases of decision support systems in land management

### **Media:**

The module relies on presentations with slides, self-learning texts and exercises, class-exercises using online repositories and applications. All materials, hyperlinks and online applications / software will be made available through Moodle. Software which will be used: decision support software (e.g. ILWIS, ArcGIS, CommunityViz).

### **Reading List:**

Articles:

- Drobne, S., Lisec, A. 2009. Multi-attribute decision analysis in GIS: weighted linear combination and ordered weighted averaging. *Informatica*, 33 (4).
- Lee, H.-S., Tzeng, G.-H., Yeh, W., Wang, Y.-J., Yang, S.-C. (2013). Revised DEMATEL: Resolving the Infeasibility of DEMATEL. *Applied Mathematical Modelling*, 37 (10-11), 6746-6757. <https://doi.org/10.1016/j.apm.2013.01.016>
- McCall, M.K., Dunn, C.E. (2012). Geo-information tools for participatory spatial planning: Fulfilling the criteria for 'good' governance? *Geoforum*, 43 (1), 81-94. Doi:10.1016/j.geoforum.2011.07.007.

Books:

- Demetriou, D. (2014). *The Development of an Integrated Planning and Decision Support System (IPDSS) for Land Consolidation*. Springer, 121 p. (ISBN 978-3-319-02347-2)
- Malczewski, J. (1999). *GIS and Multicriteria Decision Analysis*. Wiley & Sons, Inc. 394 p. (ISBN 0-471-32944-4)
- Sugumaran, R., Degroote, J. (2011). *Spatial Decision Support Systems: Principles and Practices*. CRC Press, Taylor & Francis Group. 470p. (ISBN 978-1-4200-6209-0)
- Saaty, T.L., Vargas, L.G., 2012. *Models, methods, concepts & applications of the analytic hierarchy process*. Springer Science & Business Media (ISBN 978-1-4614-3597-6)

**Responsible for Module:**

Prof. W.T. de Vries

**Courses (Type of course, Weekly hours per semester), Instructor:**

Entscheidungsunterstützungssysteme (Vorlesung, 4 SWS)

de Vries W [L], de Vries W ( Bendzko T )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU40063: Land Management International - Theory and Practice | Landmanagement International - Theorie und Praxis

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consist of a written exam of 90 minutes (only dictionary allowed as aiding material). The written exam tests whehter students are able to describe and justify why differences in land management approaches and instruments exists between countries, and are able to explain how to design a responsible solution strategy for a given case of a land management problem in any country.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

- international definitions, concepts and frameworks of land management
- types and varieties of land registration systems
- land scarcity and instruments to handle land scarcity (e.g. compact city, land conversion, land reclamation)
- land grabbing, land matrix
- urban and rural land development
- explain the notion of indigenous rights, and clarify the implications of when indigenous rights collide with conventional rights
- describe how to compare and research organisational aspects of cadastres and land registers
- Torrens land registration
- land tools of GLTN
- OICRF repository

### **Intended Learning Outcomes:**

At the end of the module students should be able to:

- explain the international definitions (the the variations thereof) of land management, land management interventions, land administration, land tenure systems
- describe the characteristics and differences in land registration systems types
- explain why in many countries no full coverage of land registration exists
- discuss the concept of the 'continuum of land rights' and explain how and why this concept is relevant at the international level
- discuss and apply the land tools of GLTN
- apply the webtool of land matrix
- apply the webtool Landmark
- explain why and how land management is different in urban areas as compared to rural areas
- explain the reasons and implication of land scarcity, and describe different strategies how to handle land scarcity
- apply the 8R framework of responsible land management
- compare strategies how to handle competition in land use
- explain the notion of indigenous rights, and clarify the implications of when indigenous rights collide with conventional rights
- describe how to compare and research organisational aspects of cadastres and land registers
- compare the characteristics of Torrens land registration with German land registration
- describe and compare international cases of land management
- apply the search tool OICRF

### **Teaching and Learning Methods:**

This module consists of two teaching modalities - a theoretical part and a practical (application) part. During the lectures theories, concepts and cases of land management are presented and explained. During the practical classes students are requested to examine a specific case study related to the concepts explained in the theoretical classes.

### **Media:**

Lectures are accompanied by powerpoint slides and introductory videos.

Practical sessions rely on case study materials and various websites, including OICRF, Land Matrix, LandMark, Landtool

### **Reading List:**

A collection of background materials

### **Responsible for Module:**

W.T. de Vries

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Land management international - practical skills (Übung, 2 SWS)

de Vries W [L], de Vries W

Landmanagement International (Vorlesung, 2 SWS)

de Vries W [L], de Vries W ( Bendzko T )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46029: Summer School of NeXus Water Food Energy | Summer School zum NeXus Water Food Energy

Version of module description: Gültig ab summerterm 2014

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>50   | <b>Contact Hours:</b><br>100         |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

Example topics include: Pesticide pertinence, water treatment, erosion and contamination from diffusive sources, Water resources management, hydrology and climate, land use and urban growth dynamics, biodiversity and restoration of aquatic ecosystems and responsibility to resources in the Nexus context. The summer school takes place in the Oskar-von-Miller Institut near Garmisch-Partenkirchen and at TUM City Campus.

The scientific format of the summer school includes both keynote talks and lectures by leading experts in the fields of life and water sciences from our partner universities and TUM, as well as project presentations by students and discussion groups. The summer school is also meant to increase the scientific collaboration and student exchange between all our partner universities and TUM.

#### Intended Learning Outcomes:

#### Teaching and Learning Methods:



**Media:**

**Reading List:**

**Responsible for Module:**

Franz Zunic (franz.zunic@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46036: Water Resources and Hydropower | Wasserwirtschaft und Wasserkraft [WRHP]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written exam (120 minutes, open book, allowed tools: notes, print medias (books, printed slides...), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

The students will prove that they are able to apply modelling techniques in water management and to design the volumes and water levels of a reservoir.

Furthermore, they prove that they can design a water power station in concept and dimensioning as well as the state-of-the-art technologies for energy storage.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Bachelor's level knowledge in hydraulic engineering, e.g.

- "Basic Module Hydraulic and Water Resources Engineering"
- "Supplementary Module Hydraulic and Water Resources Engineering"

#### Content:

The module provides in-depth knowledge of principles, methods and technologies for calculation and management of water resources, as well as the sustainable generation of energy from hydropower.

- precipitation, runoff and runoff coefficient
- rainfall-runoff modelling

- flood routing
  - flood statistics
  - reservoir capacity
  - storage plans and operation schemes
  - flood retention
- 
- types of hydro power stations, specific requirements of large and small hydro power
  - elements of hydro power installations
  - hydro turbines: turbine types, application ranges
  - stream turbines: fundamentals, turbine types, application range
  - energy conversion in hydro turbines - physical fundamentals
  - planning of hydro power stations: hydrological surveys, layout, power plan
  - needs and requirements for energy storage
  - fundamental options for power storage
  - properties of storage technologies, pros and cons, application ranges, potential, development state, project examples
  - pumped storage plants: fundamentals, electromechanical equipment, new approaches

#### **Intended Learning Outcomes:**

After successful participation in the module, students will be able

- to apply important and mainly used modelling techniques and calculation methods of water management
- to assess their application areas and limitations
- to design a reservoir under the aspects of hydrology and water resources management
- to describe, identify and assess established and newly proposed technologies of hydropower and energy storage
- to explain and assess the physical foundations of the energy conversion as well as the fundamental approach in planning hydropower projects
- to evaluate hydropower project plans and to perform planning themselves.

#### **Teaching and Learning Methods:**

- lecture style
- practical examples
- coordinated moodle tests (voluntary)

#### **Media:**

- PowerPoint presentations with film sequences and computer animations
- blackboard exercises
- moodle tests (voluntary)
- lecture notes in moodle

#### **Reading List:**

see lecture notes

**Responsible for Module:**

Dr.-Ing. Richard Huber (richard.huber@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Sustainable Water Resources Management (Vorlesung, 2 SWS)

Huber R, Scherbaum S

Hydro Power and Energy Storage (Vorlesung, 2 SWS)

Reisenbüchler M [L], Reisenbüchler M, De Vos L, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46039: Ethics in Science and Technology | Ethik in Wissenschaft und Technologie

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>90    | <b>Contact Hours:</b><br>90                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment is done on the basis of a scientific report.(max. 5 pages)

The students take part actively in the seminar and take part in the discussions. The discussions allow a continuous improvement of the argumentation competence of the students. Through the study of special texts and project examples the knowledge of social challenges of the complex "Nexus - Water-Food-Energy" is improved. Through a presentation (approx. 20 minutes) of a related topic and a written summary with individual argumentation schemes the seminar is completed.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Students must visit first the basic seminar to deepen their knowledge for the advanced seminar.

#### Content:

Scientists and engineers in science and economy at the beginning of their professional career partly face moral challenges which they are hardly prepared for in the traditional study plans. These problems can appear in public discussion or within the realisation of scientific innovations in research and industry. In a basic seminar the models of ethical argumentations are thought. Afterwards the students work on ethical challenges with realistic project examples from the Nexus complex "water-food and energy".

#### Intended Learning Outcomes:

The students develop a better understanding for the nature of the scientific work within the scope of interdisciplinary Nexus - Water, Food and Energy. They get to know the most important ethical

theories and can apply them. The students are enabled to separate technical and normative dimensions of a problem professionally and can develop criteria for a decision. The competence of problem differentiation, reflection, broad argumentation and critical power of judgement is explicitly promoted. The students can judge interdisciplinary projects.

**Teaching and Learning Methods:**

Text reading, talks preparation, problem differentiation, individual and group work, discussion, presentation and written elaboration.

**Media:**

Reader, Powerpoint, Film, Webplattform

**Reading List:**

**Responsible for Module:**

Dr. rer. nat. Eva Sandmann sandmann@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Ethik in Wissenschaft und Technologie - Teil 2 (Vorlesung, 2 SWS)

Sandmann E

Ethik in Wissenschaft und Technologie - Teil 1 (Vorlesung, 2 SWS)

Sandmann E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54011: Integrated Water Resources Management | Integriertes Wasserressourcen Management [IWRM]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a written, closed book test of 120 min duration. The exam will consist of open questions, multiple choice questions and mainly exercises which will require short computations.

Through short and precise answers to theoretical questions, the students demonstrate that they are able to understand the principles of integrated and sustainable water management; different institutional roles in the water management sector in several countries, methods and tools of integrated water resources planning and management as well as analyze and evaluate water related decision problems. The practical part is based on exercises mainly associated to the analysis and application of a preliminary IWRM plan, to the application of simulation tools for a river basin, and to the application of the most common optimization methods in water resources management problems. This will allow verifying the understanding by the students concerning the application of basic IWRM concepts, their ability to differentiate between a range of river basin management tools and models as well as apply those concepts (e.g. linear and nonlinear optimization tools) for the solution of problems within a given period of time.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge of hydology

#### Content:

1. Introduction
  - Introducing Water Resources Management
  - The Overall Problem and Main Challenges

- Need for optimized water resources management
- System Components, Planning Scales and Sustainability
- Planning and Management
- Integrated Water Resources Management
- Definition of IWRM
- IWRM History and Principles
- The enabling environment
- The institutional roles
- Management instruments
- Water Management at River Basin Scale
- IWRM and capacity development
- 2. Decision Support Systems (Short Introduction)
- 3. Water Resources Planning and Management River Basin Management Overview
  - Framework for water resources planning and management
  - Modelling of Water Resources Systems
  - River Basin Planning and Management Models
  - Modelling Methods: Simulation, Optimization, Multi Criteria Analysis
- 4. Optimisation
  - Short Introduction to Economics for Engineers
  - Introduction to optimization
  - Calculusbased methods
  - Linear optimization
  - Dynamic optimization
  - Multiobjective optimization
- 5. Multi Criteria Analysis
- 6. Uncertainty Analysis
  - Time Series Generation
  - Sequent peak algorithm and Reservoir Management

#### **Intended Learning Outcomes:**

At the end of the module, students are able to:

- understand the principles of integrated and sustainable water management,
- understand different institutional roles in several countries,
- apply linear and nonlinear optimization tools,
- analyze and evaluate water related decision problems,
- differentiate between a range of river basin management tools and models.
- understand and apply methods and software tools of integrated water resources planning and management .

#### **Teaching and Learning Methods:**

The module consists in a lecture with integrated exercises.

The teaching concept of this module is based on the fact that different study goals will be achieved using different approaches. While theoretical concepts and mathematical equations require an indepth explanation, which is provided during the lectures, the understanding of a model



requires hands-on, practical learning, which will be provided during the integrated exercises and the homework. During the lectures, the students will understand the theory behind the models. They are going to apply those models in the integrated exercises and the homework. Whenever necessary, a complementary theoretical background of the models is provided in the exercises in order to enhance the understanding of the students. In this way, at the end of the module, they will be able to create their own model from one side, of a river basin and to make an analysis of various water allocation and water resources management strategies and from the other side, to build an optimization problem and to solve it for the most important water resources problems (optimal water allocation, storage capacity – yield, reservoirs operation and groundwater supply).

Students have to bring their own laptop to the computer exercises.

**Media:**

Power-Point-Presentation, blackboard, software

**Reading List:**

- Water Resources System Planning and Management (Daniel P. Loucks)
- Global Water Partnership Technical Advisory Committee (TAC) Background paper on Integrated Water Resources Management
- <http://www.gwp.org/en/The-Challenge/What-is-IWRM/Dublin-Rio-Principles/>
- Bonn 2011 Conference proceedings The Water, Energy and Food Security Nexus, Solutions for the Green Economy
- United Nations World Water Assessment Programme

**Responsible for Module:**

Prof. Dr.-Ing Markus Disse [markus.disse@tum.de](mailto:markus.disse@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Integrated Water Resources Management (Vorlesung mit integrierten Übungen, 4 SWS)

Disse M [L], Chiogna G, Disse M, Gerner A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU66026: Shallow and Deep Geothermal Energy Use of Groundwater for environmental Engineers | Flache und Tiefe Geothermie von Grundwassersystemen für Umweltingenieure**

Version of module description: Gültig ab winterterm 2016/17

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Mit der Klausur (60 min) wird geprüft, inwieweit die Studierenden in Wissensfragen die physikalischen Grundlagen der Geothermie, die physikalischen, geologisch/hydrogeologisch relevanten Parameter und die geothermischen Prozesse beschreiben können sowie in praxisnahen Fragestellungen die Untersuchungs- und Berechnungsmethoden für die Planung und Auslegung oberflächennaher Systeme fallspezifisch anwenden, sowie die Ergebnisse aus der Datenauswertung von Feld- und Bohrdaten, auch hinsichtlich Unsicherheiten und Risiken in der Geothermie, analysieren und bewerten können.

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

Empfohlen sind Grundkenntnisse der Geologie (Einführung in die Geologie für Umwelting.), Hydrogeologie (Grundwasserhydraulik) und der Thermodynamik.

#### **Content:**

Im Modul werden den Studierenden die Grundlagen der Geothermie sowie die Vorgehensweise und andere wichtige Aspekte bei Planung, Bau und Betrieb von geothermischen Anlagen vermittelt. Die Inhalte sind im Einzelnen:

- Physikalischen Grundlagen des Wärmestroms im Untergrund
- Relevante Parameter zur Beschreibung geothermischer Systeme
- Lagerstättentypen geothermischer Systeme
- Verfahren zur Planung, Exploration und Gewinnung bei tiefen geothermischen Systemen

- Nutzungsvarianten von oberflächennahen geothermischen Systemen und ihre Planung und Auslegung
- Rechtliche Grundlagen bei der Nutzung von oberflächennaher und tiefer Geothermie
- Ökonomische Betrachtung von oberflächennahen Systemen
- Unsicherheiten und Risikoabschätzung bei geothermischen Nutzungen

### **Intended Learning Outcomes:**

Nach der erfolgreichen Teilnahme an den Modulveranstaltungen sind die Studierenden in der Lage:

- die Prozesse der Wärmeströmung im Untergrund hinsichtlich ihrer geothermischen Nutzung zu verstehen
- die Verfahren zur Erhebung und Auswertung von Daten (Felddaten, Bohrdaten) zu verstehen, welche die relevanten geothermischen Parameter abschätzen bzw. erheben.
- Verfahren zur Nutzung der oberflächennahen und tiefen Geothermie zu verstehen.
- Berechnungsmethoden zur Auslegung und Planung oberflächennaher Systeme anzuwenden, die Ergebnisse zu analysieren und zu bewerten.
- die Unsicherheiten und Risiken (z. B. Fündigkeits- und Bohrrisiken) in der Geothermie zu verstehen.

### **Teaching and Learning Methods:**

Das zu Grunde liegende Konzept des Moduls ist das problembasierte Lernen. Der Kern des Moduls besteht aus Lehrgesprächen mit Präsentationen zur Nutzung der tiefen und oberflächennahen Geothermie. Anschließend werden die Lerninhalte durch Übungen umgesetzt und vertieft werden. Die Übungen beinhalten Aufgaben zur Planung und Auslegung geothermischer Systeme und zum Verständnis der relevanten geologisch-thermischen Prozesse in der Geothermie. Hierbei werden Aufgaben gestellt, welche die Studierenden in selbstständiger Arbeitsweise analysieren sollen. Die Ergebnisse der Studierenden werden in der Gruppe diskutiert und der Lösungsweg aufgezeigt. Die Ergebnisse der Übungen werden den Studierenden auf der e-learning Plattform zur Verfügung gestellt um den Lösungsweg in der Nachbearbeitung überprüfen zu können. Die Vorlesung und Übung wird nach Bedarf und Möglichkeit durch Gastdozenten aus der Praxis unterstützt.

### **Media:**

Moodle e learning Plattform, wiki-Plattform, Power-Point Präsentationen, Übungsaufgaben am PC, Lehrgespräche, Diskussion, Gruppenarbeit

### **Reading List:**

BANKS, D. (2012): An Introduction to Thermogeology. – Ground source heating and cooling. 2nd Edition, 526 S., Wiley-Blackwell, Sussex.

DIPIPO, R. (2012): Geothermal Power Plants. – Principles, Applications, Case studies and Environmental Impact. – 600 S., Elsevier, Amsterdam.

GRANT, M. A. & BIXLEY, P. F. (2011): Geothermal Reservoir engineering. 2nd Edition, 359 S., Academic Press , Burlington.

HUENGES, E. (2010): Geothermal Energy Systems: Exploration, Development, and Utilization. - 463 S., Wiley VCH, Weinheim.

KALTSCHMIT, M., HUENGES, E. & WOLFF, H. [Hrsg.] (1999): Energie aus Erdwärme. – 265 S., Spektrum, Heidelberg.

KOENIGSDORFF, R. (2011): Oberflächennahe Geothermie für Gebäude. – 332 S., Fraunhofer IRB, Stuttgart.

OCHSNER, K. (2007): Geothermal Heat Pumps – A Guide for Planning and Installing. – 224 S., Cromwell Press, Trowbridge.

THOLEN, M. & WALTER-HERTKORN, S. (2008): Arbeitshilfen Geothermie. – 228 S., WVGW, Bonn.

**Responsible for Module:**

Kai Zosseder, [kai.zosseder@tum.de](mailto:kai.zosseder@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Einführung in die oberflächennahe und tiefe Geothermie (Vorlesung mit integrierten Übungen, 3 SWS)

Zoßeder K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV170051: Energy Economics and Hydro Power | Energiewirtschaft und Wasserkraftanlagen

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                               |
|--------------------------------|-----------------------------|----------------------------------|-------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>one-time |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30   |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam in this module is a written exam of 60 minutes in which the students have to answer questions in the field of energy topics, both economics and technical aspects in a closed books exam.

The comprehension of the lecture contents is also checked by some transfer questions, which are oriented on the presented exemplary areas of application.

#### Repeat Examination:

#### (Recommended) Prerequisites:

For Master students in Environmental Engineering:

Course only available as part of module "Energy Economics, Hydro Power and Energy Storage" (BGU46023).

Bachelor in Civil Engineering or Environmental Engineering.

#### Content:

Energy mix, power gap, increase of oil price, price fixing, nuclear phase out, grid stability, primary energy reserves, Kyoto protocol, CO2 emission trading, power prices, power trading, security of supply, environmental compatibility: These are the topics dominating the news when it comes to energy economics. How do these issues relate to each other? Which rules do energy economics follow? Conventional power or renewable energies: Contradiction or complement? What about the Interaction between energy economics and legislation, society, media or politics?

Hydro power plays a particular role within energy economics. Therefore the second part of the lecture deals with hydro power, being the most important renewable energy. Questions to be discussed will be: What are the potentials of hydro power? What is hydro power's relevance concerning the power mix? Based on a real example of a hydro power project issues as approval procedure, economics calculation, planning, construction, operation and maintenance strategy will be presented. Also this part of the lecture will demonstrate the numerous interfaces between engineering and other aspects linked to it.

**Intended Learning Outcomes:**

At the end of the module students are able to contribute to discussions with the various stakeholders on energy economics and know the various options of power production and its implications. They get an insight in the complex structure of energy and power supply from upstream to downstream.

**Teaching and Learning Methods:**

The lecture is aimed at providing insight into the various aspects of energy economics and at imparting knowledge to the engineer as a basis for working in an unusual and interesting environment. PowerPoint presentation and blackboard explanation for visualizing the topics. There are also discussions with the students during the lectures so they can get a deeper insight in practical experience with the topics.

**Media:**

PowerPoint presentation and blackboard explanation.

**Reading List:**

**Responsible for Module:**

Yannic Fusch (yannic.fuchs@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CS0073: Circular Economy | Circular Economy [CEC]

Version of module description: Gültig ab winterterm 2021/22

|                                  |                             |                                  |                                      |
|----------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6            | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Written exam (90 minutes): Students have to analyse, assess and discuss (simplified) circular economy concepts and legislative frameworks on a local, regional, national and global level, determine starting points for an optimisation of these concepts and apply them to real-life use cases. Thereby, they have to take different points of view (environmental, product, (material flow) system, macroeconomic, business). In doing so, the students have to prove their ability to use the right vocabulary, and their knowledge on the motivation and key figures of circular economy.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

The module covers the following topics:

- Circular Economy as a concept to approach sustainability needs
- History and policies related to the development of a circular economy
- CE Schools of thought
- Natural / biogeochemical material cycles as role models for the CE
- Assessing environmental impacts in a CE
- Assessing CE from a material perspective
- CE from a macroeconomic perspective
- Value Creation and emerging business models in a circular economy
- Design for Sustainability
- Special topics and use cases

**Intended Learning Outcomes:**

Students explain the importance of the circular economy within the context of resource shortages, climate change and further sustainability challenges. They discuss and understand the central concepts of a circular economy against their historical background covering both, traditional waste management and recycling approaches as well as more recent holistic concepts. They assess and discuss CE from an environmental, product, material, and economic perspective. Based on these competences, they can develop action approaches to transfer these concepts from theory into practice. They link independently urgent environmental problems of our time with the concept of the circular economy and design solution approaches based on their results. Regarding value creation in a circular economy, the students identify business opportunities, develop and discuss new innovative business models. They apply these concepts to specific use cases, and assess their implications from different perspectives.

**Teaching and Learning Methods:**

Format: lecture and exercises to introduce the content, to repeat and deepen the understanding as well as practice individually and in groups.

Teaching / learning methods:

- Media-assisted presentations
- Group work / case studies / reading of scientific publications with presentation
- Individual assignments and presentation to consolidate/repeat the learned contents
- Dismantling and recycling exercises in the CE-lab
- Plenary discussions to reflect the lecture contents

**Media:**

Digital projector, board, flipchart, online contents, case studies, computer lab

**Reading List:**

Recommended reading:

- Ayres, Robert U. (2002): A handbook of industrial ecology
- Baccini, Peter (1991): Metabolism of the Anthroposphere, Springer
- Baker-Brown, Duncan (2017): The re-use atlas a designer's guide towards a circular economy
- Charter, Martin (2019): Designing for the circular economy, Routledge
- De Angelis, Roberta (2018): Business Models in the Circular Economy: Concepts, Examples and Theory, Palgrave Macmillan
- Franco-García, María-Laura ; Carpio-Aguilar, Jorge Carlos ; Bressers, Hans: Towards Zero Waste: Circular Economy Boost, Waste to Resources, Springer
- Larsson, Mats (2018): Circular Business Models: Developing a Sustainable Future
- Schaub, Georg; Turek, Thomas (2016):
- Energy Flows, Material Cycles and Global Development: a Process Engineering Approach to the Earth System, Springer
- Webster, Ken (2017): The Circular Economy - A Wealth of Flows, Ellen MacArthur Foundation Publishing



**Responsible for Module:**

Prof. Magnus Fröhling

**Courses (Type of course, Weekly hours per semester), Instructor:**

Circular Economy (Lecture) (Vorlesung, 2 SWS)

Fröhling M [L], Fröhling M

Circular Economy (Exercise) (Übung, 2 SWS)

Fröhling M [L], Heinrich V

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **EI7467: Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country | Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country [ProRESDC]**

*Interdisciplinary Student Project Concept Development of a Renewable Energy System in a Developing Country*

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>135  | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The students' learning success will be determined by the following components of the project:

1. Input throughout the course of the milestone meetings (the supervisor of a team will rate each member of his team individually based on her or his input during the milestone meetings):
  - Integration of the extraneous inputs, which his team members from other fields of study give, in order to develop a holistic concept for a renewable energy system in a developing country
  - Analyzing the framework conditions, determining obstacles and deriving innovative solutions for renewable energy systems in developing countries before each milestone meeting
  - Communication with the team leader and the other team members
  - Meeting the timetable
2. Final presentation:

A jury will evaluate, how far the team manages to transfer their developed concept into an understandable context and to convince the audience of their choice of a certain concept. This includes the logic of the presentation, the focus on relevant points and appealing visualizations of their presentation slides.

In addition to this, each team member is individually evaluated for her or his presentation methods and expertise shown during the subsequent questions.
3. Project report (identical evaluation of all team members):

Here is rated how much convincing the decision was explained for the chosen energy concept and against other possible concepts due to the technological, financial and socio-cultural conditions and how comprehensible the implementation of the final concept was described.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

- Bachelor degree in a technical field of studies or in TUM-BWL
- Participation in "Series of lectures Renewable Energy Systems in Developing Countries"
- Interest in energy systems and their application / realization in developing countries
- Interest in the conversion of knowledge, which may differ from the field of her or his own studies on the one hand , but on the other hand is essential for the holistic understanding of their own study curriculum
- Interest in team-based project work and developing a realizeable concept
- Letter of motivation regarding study program, expertise, motivation and relevant experience (1.000 - 2.000 characters)

**Content:**

During the study project students develop a concept for the renewable energy system of a given location in a developing country.

During this concept development the variety of possible energy concepts will be reduced by general characteristics of stand-alone systems in the first step, followed by technological criteria in developing countries and socio-cultural impacts. Subsequently, the suitability of the various power production technologies, which are presented in the lectures, will be evaluated for the site in the developing country. Afterwards financing possibilities and framework conditions of regional market will be taken into account for the selection of the energy concept. In the end the final energy concept will be derived out of these sub steps.

Additionally the students derive options based on their developed energy concept, how to empower the population of the region economically by means of renewable energies.

**Intended Learning Outcomes:**

After participating in the project the students will be able to:

- understand extraneous knowledge concerning renewable energy systems in developing countries by the interdisciplinary collaboration with students from different study fields
- implement this interdisciplinary knowledge about energy systems in developing countries into action competences
- present the progress of a project target-oriented in meetings
- highlight the relevant technological, financial and sociocultural framework conditions of a planned energy system for a certain location in a developing country
- evaluate various options of energy supply concepts with based on their framework conditions
- manage the progress of a concept
- develop a suitable energy concept based on the requirements and possibilities of a defined location

- present convincingly their concept in a final presentation
- describe convincingly in a project report both the choice of their energy concept taking the involvement of all relevant aspects into account and the its realization

### **Teaching and Learning Methods:**

Students are expected to achieve the learning outcomes by means of a project internship. Interdisciplinary teams of students, consisting of students from various faculties, develop a concept for a renewable energy system for a particular location in a developing country in defined milestones. Each team is advised by a scientific assistant, who is their team leader. This advisor is managing the technical expertise of the team members with her or his project experience during the weekly milestone meetings.

Finally, each team presents its energy concept in a final presentation and in a project report. As a closing event there is offered a two-day excursion to an alpine mountain hut in Tyrol. Here both the the pros and cons of the concepts developed by the students are discussed to give the students the opportunity to reflect on their own work and that of their fellow students. Also the island energy system of the alpine hut, consisting of PV, biomass and battery storage, is shown in order to experience a realization of such a low-budget energy system.

### **Media:**

- Practical presentation of components using PowerPoint slides and scripts for the subsequent experiments (practical events)
- PowerPoint slides to define the milestones (milestone meetings)
- Final presentation using PowerPoint
- Project report using Word or Latex

### **Reading List:**

- Engineers without Borders UK in 2014 - Engineering in Development
- Scripts for each practical event
- Other thematic literature on the recommendation of the speakers of the lecture series

### **Responsible for Module:**

Hamacher, Thomas; Prof. Dr.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Interdisziplinäres Projektpraktikum Konzeptentwicklung eines Erneuerbaren Energiesystems in einem Entwicklungsland (Forschungspraktikum, 4 SWS)

Hamacher T, Bazan S, Cadavid Isaza A, Pant P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### POL62400: Environment and Climate Transformation | Environment and Climate Transformation

Version of module description: Gültig ab winterterm 2017/18

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

For this module, evaluations will be based on written work and in cases of simulations will also be participative. Written assignments will entail either two seminar papers (one paper per seminar each of about 10 pages), a term paper of about 20 pages, or participation in a simulation, including written preparatory work therefore. Seminar papers are to be written during the semester while term papers can also be written in the time between semesters. In the case of simulations, the written preparatory work is to be done during the seminar. The topic of the seminar papers is to be developed in consultation with the seminar leader and should deal with a specific topic of the seminar, which is introduced with a precise question and then analyzed in depth. For a term paper, a broader topic which has been covered in at least one of the seminars is to be addressed. The term paper should be guided by a precise question which is then analyzed in depth. Students have the opportunity to choose for which seminar they wish to prepare a term paper. As course work, students will be expected to prepare and make a presentation of at least 20 minutes in both courses on a theme being discussed in class. Group presentations of up to three students are possible.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Ring lecture „Politics & Technology“

#### Content:

Global climate change, biodiversity loss, resource depletion, ocean acidification, and land degradation are some of the many environmental problems which have potentially grave consequences for humanity. These consequences are noticeable at the local, regional, national and international levels. This module considers both the impacts of environmental problems on

today's societies as well as the potential implications for future generations. It also considers various technological-and social responses to these problems at the regional, national and international level.

### **Intended Learning Outcomes:**

This module will help students identify key concepts and theories tied to environmental and climate politics at the local, national, European and global levels, to understand decision making processes, and to work with different environmental policy instruments (for example legal regulation, planning, incentive design, taxes, subsidies, etc.). Students will be able to recognize and make use of different negotiation strategies. They will be able to consider the strengths and weakness of a variety of regulatory and non-regulatory governance instruments, develop leadership skills, understand the importance of issue framing, and consider the importance of coalitions. They will gain an awareness of different theoretical and methodological approaches to environmental and climate politics research and will be able to apply methods of comparative analysis to environmental and climate politics at the regional, national, and international levels. The inter- and intra-generational justice aspects of environmental and climate policy making (or lack of action) will be considered along with the implications of different technological, economic, and social solutions. The course will be global in its scope examining both developing, transitioning, and technologically developed countries.

### **Teaching and Learning Methods:**

The module is offered in the form of two seminars, each dealing with different, but complementary thematic areas. One should be focused more on technological, social, and intergenerational justice implications of environmental, energy, and climate decision making while in the other seminar the students have the opportunity to model political decision-making and negotiations. As a goal of the module is to strengthen students' negotiating skills, in-class simulations will be developed (e.g. of global climate or biodiversity negotiations or of negotiations among European countries). This may include a weekend or alternative extra-long session to allow for a full-length negotiation. Seminars will include both direct input from the instructor and modelling of domestic and international negotiations. Active participation in seminars will be essential. In-class negotiations or decision making simulations will be complemented by written reflection pieces. The presentations developed and given by the students during and after simulation exercises will contribute to the students' understanding of how decision making and negotiations function.

### **Media:**

Online-Reader, PowerPoint

### **Reading List:**

A reader of seminar texts with up-to-date and cutting edge scientific literature will be made available at the start of the semester.

### **Responsible for Module:**

Schreurs, Miranda; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

(POL62400) Environment and Climate Transformation (- Seminar 1) (Seminar, 2 SWS)  
Ohlhorst D ( Mohammed N, Schreurs M )

(POL62400) Environment and Climate Transformation (- Seminar 2) (Seminar, 2 SWS)  
Schreurs M ( Mohammed N, Schreurs M )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### POL62500: The Ethics and Politics of Existential Global Risks | The Ethics and Politics of Existential Global Risks

Version of module description: Gültig ab winterterm 2017/18

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Students will write an advanced research paper (18-20 pages) in one of the seminars, which contains independent research, and which is handed in at the end of the term break after the semester in which the module is taught. Through this research paper, they show their ability to understand a complex and cutting-edge topic in political theory, to identify open research questions, to formulate a research agenda, to collect literature and to research material, and to compose a paper that is well-argued and up to current standards of research. During the semester students compose three written pieces: two short papers (2-3 pages) responding to a given week's reading, and (before the end of the semester) an initial research plan (2 pages) containing their research question and outlining their intentions for the final paper. The average grade of these pieces and the grade of the final research paper multiplied by three will form a sum; this sum will be divided by four to arrive at the final grade. Students may be offered the opportunity to receive a grade bonus of 0,3 for oral contributions, e.g. presentations; details will be announced at the beginning of each seminar.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Political Theory I and II

#### Content:

Seminar 1, "Uncertainty, knowledge, responsibility" discusses basic normative questions about how human beings should deal responsibly with uncertainty and risk. Themes may include: how do moral theories, such as consequentialism, deontology and virtue ethics, differ with regard to their ability to provide guidance in situations of uncertainty and/or high risks; what is the responsibility of experts as bearers of knowledge? Seminar 2, "Climate Ethics and Climate Justice", introduces



students to the normative dimensions of climate change. Themes may include: the individual and the political level of responsibility, the specific features of climate change as a global commons problem; ethical, political and technological proposals for responding to climate change; the ethical permissibility and political feasibility of climate engineering. NOTE: Instead of taking these two seminars, and depending on teaching capacities, students might be given permission to replace one of them with a seminar on related themes from a different module.

### **Intended Learning Outcomes:**

In this module students bring together their previously acquired knowledge of debates in political theory as well as knowledge of technological and political developments in order to become able to cogently analyze selected questions of the ethics and politics of existential global risks, with a special focus on technical and environmental risks. Human agency, including political agency, takes place not only under conditions of quantifiable risk, but also under conditions of fundamental, and unquantifiable uncertainty. What does it mean to act responsibly under such circumstances? While much technology is based on the Baconian idea of subjecting nature to human control by understanding its laws, technological developments have contributing to creating new risks, both for nature and for the human race. In the module, students will learn to analyze the normative dimensions of actions under risk and uncertainty, with a special focus on climate risks and technological responses to it. Questions include: What kind of responsibility comes with (technical) knowledge? Does the fact that we may not know the exact effects of our behavior diminish our moral responsibility? What forms of climate engineering are ethically justifiable?

### **Teaching and Learning Methods:**

This module consists of seminar courses and substantial independent research on the part of students. Students submit three pieces of written work throughout the semester: two response papers addressing problems raised in assigned readings, as well as a preliminary research plan for the final paper at the end of the semester. The seminar sessions are discussion-based and highly interactive, and will combine working through complex political issues and a discussion of student response papers.

### **Media:**

Literature, Powerpoint, Whiteboard

### **Reading List:**

Literature will be provided on moodle. Exemplary texts include: Knight, Frank. Risk, Uncertainty, and Profits. Mineola: Dover Publications (2006 [1921]), Young, Iris Marion. 2011. Responsibility for Justice. Oxford: Oxford University Press, Weick, Karl E., and Kathleen M. Sutcliffe. 2001. Managing the Unexpected. San Francisco: Jossey-Baas, Oakley, Justin and Dean Cocking. 2002. Virtue Ethics and Professional Roles. Cambridge: Cambridge University Press, Jamieson, Dale. 2008. Ethics and the Environment: An Introduction. Cambridge: Cambridge University Press, Gardiner, Stephen et al. (eds.). 2010. Climate Ethics: Essential Readings. Oxford: Oxford University Press. Hardin, Garrett. 1968. "The Tragedy of the Commons." Science. Mulgan, Tim. 2011. Ethics for a Broken World: Imagining Philosophy After Catastrophe. Montreal / Kingston-Itacha: McGill-Queen's University Press.

**Responsible for Module:**

Schreurs, Miranda; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

(POL62500) The Ethics and Politics of Existential Global Risks (Part 1) (Seminar, 2 SWS)

Ohlhorst D ( Mohammed N )

(POL62500) The Ethics and Politics of Existential Global Risks (Part 2) (Seminar, 2 SWS)

Ohlhorst D ( Mohammed N, Schmid H )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001255: Lecture Series Renewable Energy Systems in the Global South | Ringvorlesung Erneuerbare Energiesysteme im Globalen Süden

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>135  | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Written exam of 60 minutes:

- In multiple-choice questions and short questions, it is examined if the students are able to name and explain facts regarding renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South correctly.
- In computational tasks, it is examined if the students are able to classify relevant location parameters correctly and perform calculations on renewable energy technologies correctly in order to design decentralized energy systems in the Global South according to the framework conditions of a certain location.
- In text tasks, it is examined if the students are able to classify and evaluate technological, economic and social factors influencing renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South correctly.
- The exam is graded.
- Up to 20% of the exam can be multiple-choice questions.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Bachelor degree in an engineering study program or a study program, which included technological/engineering aspects (such as B.Sc. Management & Technology)
- Interest in various renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South
- Interest in the socio-economic factors influencing the utilization of renewable energies in the Global South

### **Content:**

Overview of renewable energy technologies including their functionality, their technological and economical assessment, their integration in decentralized energy systems as well as business concepts for their utilization in the Global South:

- Renewable energy systems in the Global South - Why and how?
- Small-scale solar thermals and photovoltaics
- Small-scale hydro-power
- Small-scale wind-power
- Small-scale biogas systems
- Battery storages
- Electrical components of mini-grids
- Rural electrification planning through Geo Information Systems
- System sizing through least-cost modelling
- Sustainable energies and entrepreneurship in the Global South
- Sustainable enterprises for Renewable Energies in the Global South
- Rural electrification projects in the Global South

### **Intended Learning Outcomes:**

After successfully completing the module, students are able to

- Name and explain facts regarding renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South.
- Perform calculations regarding renewable energy technologies in order to be able to design decentralized energy systems in the Global South.
- Classify and evaluate technological, economic and social factors influencing renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South.
- Develop concepts for decentralized energy systems in the Global South based on the technological, economic and social framework conditions of a certain location.

### **Teaching and Learning Methods:**

Lectures and presentations by various researchers from TUM as well as entrepreneurs and other experts from the field of Renewable Energies in the Global South.

In exercise lessons, the taught knowledge of the lectures are applied to exemplary topics. After each lecture, the students conduct these exercises in homework and afterwards, these are discussed during the upcoming exercise lesson. Most of these exercises are calculating tasks about the technical components, but there are also some exercises regarding the financial assessment of renewable energy technologies. The exercises are not graded.

### **Media:**

The following media types are used:

- Computer-aided presentations for the lectures
- Exercises
- Discussion of provided literature

**Reading List:**

- Presentation slides of the speakers
- Solutions of exercise lessons
- Other literature recommended by the speakers

**Responsible for Module:**

Belz, Frank-Martin; Prof. Dr. oec.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ1344: Urban Agriculture | Urban Agriculture

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module grade is based on a written report (approx. 20 pages; 80% of grade) complemented by a group oral presentation (15 min. + 5 min. discussion; 20% of grade). In the report, the students design a strategy for ecologically-oriented sustainable urban agriculture. Here, students should situate their strategy in a theoretical framework, and evaluate the relevant ecological and social context of their strategy. Written summaries measure the student's understanding and evaluation of ecological and social aspects, and ability to apply theoretical frameworks. In the presentation, the students collectively present their strategy (PowerPoint plus any additional aides) to demonstrate understanding of an urban agriculture system, communicative competence, presentation and discussion skills in front of an audience.

#### Repeat Examination:

Next semester / End of Semester

#### (Recommended) Prerequisites:

Basic knowledge in ecology, agriculture, landscape ecology is an advantage

#### Content:

Urban agriculture has experienced a renaissance in recent decades. What are the possibilities for sustainable urban agriculture that supports multiple ecosystem services? This module explores ways in which urban agriculture can aid in the enhancement of food security, biodiversity, energy conservation, public health and well-being in cities. We will discuss the agro-ecological basis of urban horticultural production systems adapted for city environments. Topics include fundamentals of horticulture, soil properties and fertility, pest and pollinator management, animal agriculture, and climate change impacts. The students will learn about methods of urban agriculture and innovative approaches to ecologically-oriented and climate-resilient urban agriculture. In addition, they will study how urban food production interacts with social, cultural, and political dimensions

of urban environments (e.g. city policy, economics, human health) to foster an interdisciplinary understanding.

**Intended Learning Outcomes:**

On successful completion of the module, participants are able to:

1. understand important ecological aspects of urban agriculture such as biodiversity, soil management and climate mitigation;
2. relate social aspects of urban agriculture to ecological aspects such as public health and urban policy;
3. apply ecological theoretical frameworks to urban agricultural systems;
4. evaluate the ecological and social context of urban agriculture;
5. create a strategy for a sustainable urban agricultural system in a project;
6. communicate their strategy with understanding and evidence.

**Teaching and Learning Methods:**

The module is highly interactive and combines lectures with field trips and presentations from guests and peers. The lecture series will cover topics including: fundamentals of horticulture; soil management; pest and pollinator management; urban agriculture and climate change; challenges of urban agriculture; public health; and the business of urban agriculture. The seminars are based in experiential learning. In the seminars, we will 'see' cities as edible: in the present on field trips; in the past through films and advanced readings; and in the future through group presentations that design urban farming systems for future cities.

**Media:**

PowerPoint, films, virtual lectures

**Reading List:**

**Responsible for Module:**

Egerer, Monika; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Edible Cities (Seminar, 2 SWS)

Egerer M

Urban Agriculture (Vorlesung, 2 SWS)

Egerer M [L], Egerer M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ2730: Climate Change - Science, Impacts and Adaptation, Mitigation | Climate Change - Science, Impacts and Adaptation, Mitigation

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Due to Corona, the form of examination has changed as follows.

Assessment consisting of exercises. In a written test (Klausur, duration 60min, 60% of the module grade) the student is expected to demonstrate that he/she has understood the physical basis of the climate system and that they can identify the drivers of climate change.

In three graded exercises the student shows that he/she is able to apply his/her knowledge to develop adaptation and mitigation measures and to argue in discussions on climate change issues. The students prepare a video in groups including a role play of a panel discussion to develop their persuasive and critical skills as organizers and presenters, they become more familiar with political decision-making processes. The video is presented and discussed with all students participating. The grade for the seminar counts 40% of the module it consists of three equally weighted grades for each exercise.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in meteorology, physics, biology.

#### Content:

Based on the newest IPCC report (AR 5) the theoretical background on the physical science basis of climate change, theory and practical application of adaptation and mitigation measures in biological, physical and chemical systems will be presented. In a related seminar, selected topics will be intensified in case studies. TUM as a NGO in the UNFCCC process offers an optional possibility also for students to take part in COP and related negotiations.



**Intended Learning Outcomes:**

After this module, the students can understand the physical basis of the climate system, identify all drivers of climate change and falsify common arguing of "climate sceptics". They can summarize observed changes in the climate system as well as impacts in divers systems and regions. They are able to assess cross-sectorial impacts of climate change in selected areas, to evaluate and develop adaptation and mitigation measures and strategies in biological, physical and chemical systems including an analysis of their effectiveness and cost-effectiveness.

**Teaching and Learning Methods:**

Lecture on physical basis of the climate system, impacts of climate change and important mitigation strategies. In the seminar group presentations of various topics regarding adaptation and mitigation of climate change will be presented as case studies. Optional excursion to UNFCCC meeting if applicable.

**Media:**

Lecture with PowerPoint Presentation, reader and exercises. Group work in seminar including problem driven case studies and student presentations, excursion.

**Reading List:**

IPCC (2013) Fifth Assessment Report of WGI, II, III. Houghton (2015) Global warming, the complete briefing. Most recent scientific literature.

**Responsible for Module:**

Rammig, Anja; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Ecological, social and economic aspects of CC impacts, adaptation and mitigation on different scales (Seminar, 2 SWS)

Estrella N [L], Menzel A, Estrella N, Ghada W

Climate Change - The complete briefing (Vorlesung, 2 SWS)

Rammig A [L], Rammig A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ4189: Fisheries and Aquatic Conservation | Fisheries and Aquatic Conservation

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Current information regarding the limited activities with physical presence due to the CoViD19-pandemic:

In case the framework requirements (hygienie, distance rules etc.) for examinations with physical presence are not met, the planned examination format can be changed to a digital (remote) examination according to §13a APSO. The decision on this change will be communicated as soon as possible, however latest 14 days before the actual examination date, by the responsible examiner in coordination with the examinations board.

The examination consists of a 60 min. written exam (Klausur). In addition, the students need to prepare a 10-15 min. presentation in the practical exercise. Gradings from the examination and the presentation are weighed in the ratio 2:1.

The examination means to measure the student's ability to assess anthropogenic influence on aquatic ecosystem functioning, evaluate the socioeconomic importance of fisheries and aquaculture, explain factors affecting susceptibility to and recovery from overexploitation and recall fisheries management tools for wild populations as well as of the underlying biological principles such as fish population dynamics. In the written examination students demonstrate by answering questions under time pressure and without helping material their theoretical and practical (e.g. application of methods) knowledge about fisheries management. For answering the questions, the students require their own wording.

In the practical exercise the students prepare a presentation in form of a brochure, poster, video or podcast. For the presentation, the student is expected to demonstrate that he or she is capable of preparing a certain topic within a given time frame in such a way as to present or report it in a clear and comprehensible manner to specific target audiences in the context of fisheries and aquatic conservation.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

Interest in aquatic biology, social sciences, conservation biology and management; this course can be selected

independently from other courses in the fields of Fish Biology and Limnology at TUM

**Content:**

The module combines the theoretical background and the practical implementation of fisheries management and aquatic conservation. The key aspects are:

1. Introduction to fish, shellfish and fisheries management,
2. The socioeconomic importance of fisheries and aquaculture,
3. The functioning of aquatic ecosystems and the impacts of fisheries on aquatic ecosystem health,
4. Factors affecting susceptibility to and recovery from overexploitation,
5. Fisheries Management Tools for wild populations,
6. Aquaculture,
7. Aquatic Biodiversity Conservation,
8. Case study and knowledge transfer/communication exercise

**Intended Learning Outcomes:**

At the end of the module students understand the importance of aquatic resources for mankind and the variables which influence ecosystem functions as well as the principles of aquatic biodiversity conservation. They are able to analyze the effects of natural and man-made disturbances in aquatic ecosystems (e.g. overexploitation) based upon an interdisciplinary understanding of methodological aquatic and fisheries biology, human dimensions, socioeconomic factors and management skills. In addition, students are able to objectively integrate knowledge from different disciplines (e.g. fish biology, conservation biology, commercial fishing techniques, aquatic habitat assessment and management) to evaluate sustainable resource management.

**Teaching and Learning Methods:**

The module combines a lecture "Fisheries Management" with an accompanying practical exercise "Applied Aquatic Conservation". The lecture contents will be presented using lectures based on power-point presentation, group work and interactive role plays in order to combine activating teaching methods with classic presentation techniques. In the accompanying practical exercise to the lecture the students will apply the gained theoretical knowledge by conducting case studies or participating research experiments with various content in the field of freshwater ecology and aquatic conservation. The content of the practical work is incorporated into running research projects at the chair (e.g. habitat restoration, artificial breeding programmes, habitat assessment, conservation genetics). Additionally, the students learn to independently screen the respective literature in this field and learn methods in science communication.

**Media:**

Form of presentation: lecture, case study, movie segment and practical exercise  
material: lecture notes, flip-chart/board, plus different materials for methodological/technical training

**Reading List:**

1. King (2007) Fisheries Biology, Assessment and Management
2. Helfman (2007) Fish Conservation: A guide to understanding and restoring global aquatic biodiversity and fishery resources
3. Moyle & Cech (2004) Fishes An introduction to Ichthyology
4. Primack (2008) A primer of conservation biology

**Responsible for Module:**

Geist, Jürgen; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Fisheries Management (Vorlesung, 2 SWS)

Geist J

Applied Aquatic Conservation (Übung, 2 SWS)

Geist J [L], Bayerl H, Geist J, Pander J, Stoeckle B, Zingraff-Hamed A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Personal Elective Modules | Individuelle Wahlmodule

### Module Description

#### AR17041: Climate responsive Building II | Klimagerechtes Bauen II

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Duration time 60 minutes. Written exam.

At the end of the module the proof of performance will be a written examination. In the exam the students proof that they are able to evaluate the complex correlation of climate responsive and energy optimized building. On the basis of practical examples it is examined that the students are able to create appropriate measures and concepts. Content is over the whole semester. Answers can be given in own words or given single-choice-questions. Furthermore basic calculations should be solved.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

- Olfactory, visual and acoustic comfort
- Climate responsive building: architecture strategies (passive) to optimize the building climate and energetic supply of buildings through an integrated planning approach
- Integration of building's envelope and building technology (adjusting screw of the facade and adjustment of facade and room conditioning)
- Room conditioning: ventilation, lightning
- Technical building installation
- Daylight usage and sun protection, energy-efficient artificial lighting systems
- Simulation tools

- Legal and energy economical framework

### **Intended Learning Outcomes:**

At the end of the module students are able to:

- name the correlations between the building's envelope and the required comfort demands and apply the resulting knowledge
- design holistic, climate responsive and energy optimized building concepts
- create sustainable concepts of room conditioning
- evaluate passive (architectural) measures for minimizing the energy demand of buildings while optimizing the comfort
- adapt individual technical systems of room conditioning to the building concept or coordinate the individual systems among themselves
- analyse practical examples with regard to climate responsive and energy optimized buildings
- understand the current political and scientific state of debate regarding to buildings and urban structures in the context of the energy revolution
- on this state of knowledge suitable systems and technologies can be chosen and founded

### **Teaching and Learning Methods:**

The practical relevance is established by current projects and students' discussion. In the weekly lectures the content of the module is mediated in form of lecture and presentation and tested in a written exam.

### **Media:**

PowerPoint presentation, script, blackboard

### **Reading List:**

|                                |                                             |                      |
|--------------------------------|---------------------------------------------|----------------------|
| ClimaDesign                    | Gebäude die mit weniger Technik mehr können |                      |
| Hausladen,Saldanha,Liedl,Sager | Callwey Verlag                              |                      |
| ClimaSkin                      | Hausladen,Saldanha,Liedl                    | Callwey Verlag       |
| Ausbauatlas                    | Hausladen,Tichelmann                        | Edition Detail, 2009 |

### **Responsible for Module:**

Vohlidka, Philipp; Dipl.-Ing. (Univ.)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Klimagerechtes Bauen II (Vorlesung, 2 SWS)

Auer T, Vohlidka P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### AR17054: Conceptual Fire Prevention | Konzeptioneller Brandschutz

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Oral exam at the end of the semester about the lecture series as well as case studies.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

#### Content:

This seminar is about the relationship between fire prevention and the modes of action within a fire protection facility. The focus is on the understanding of the influence of the fire protection requirements on the construction and the surface. Furthermore the terminology and the legal standards will be explained.

#### Intended Learning Outcomes:

#### Teaching and Learning Methods:

#### Media:

#### Reading List:

#### Responsible for Module:

Giertlová, Zuzana; Dr. rer. silv. habil.

#### Courses (Type of course, Weekly hours per semester), Instructor:

Konzeptioneller Brandschutz (Vorlesung, 2 SWS)

Giertlová Z, Berghofer E, Zettelmeier C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### WI000091: Corporate Finance | Corporate Finance

Version of module description: Gültig ab summerterm 2021

|                                  |                             |                                  |                                      |
|----------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6            | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The grading is based on an open-book e-test with a duration of 90 minutes. This exam consists of theoretical questions regarding corporate finance (e.g. characteristics of real options, when to apply which company valuation method, theoretical considerations on the optimal capital structure) as well as performing applied computations (e.g. valuing real options, computing equity values by discounting cash flows, adjusting firm risk measures for leverage). The theoretical questions are mainly based on the lecture whereas the calculations are mainly based on the tutorial.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The student should have a solid understanding of finance fundamentals (discounting cash flows, risk, CAPM). These topics are covered in the course "Investitions- und Finanzmanagement" or in other introductory finance classes.

#### Content:

The module covers fundamental concepts in corporate finance. This knowledge is important as a fundament for advanced courses in corporate finance as well as a career in the investment banking or in a corporate treasury department.

- Options: Basic understanding, put call parity, binomial and Black-Scholes option pricing, equity as call option
- Real options: Identification and binomial pricing
- Valuation: Introduction to DCF methods, multiples methods and applications
- IPO: Empirical studies of IPO costs, IPO process
- Capital structure: WACC under OPM, CAPM and MM, trade off theory of debt, agency theory of debt, pecking order theory of debt

- Efficient markets: Definitions, modeling, empirical approaches and results
- M&A: Explanations of wealth effects of M&A, explanations for conglomerates, Empirical results on other forms of ownership decreases and change (divestitures, carve outs, spin offs, tracking stock, split ups, LBOs)
- Dividend policy: Theories of optimal dividend policy, Empirical evidence

### **Intended Learning Outcomes:**

After successful completion of the module, students will be able to explain the most common concepts in corporate finance such as real and financial options, company valuation, market efficiency and dividend and leverage policies. Furthermore, they are able to discuss critically these topics. Finally, they will be able to apply the above concepts and decide on corporate financial policies as well as evaluate financial and real options and companies (e.g., by using option theory or DCF methods).

### **Teaching and Learning Methods:**

There is a weekly lecture and tutorial. During the lecture, the content is presented with the help of slides and computations on a tablet computer. Students can gain a deeper understanding by solving the weekly problem sets. The solution to these problem sets is presented each week during the tutorial.

### **Media:**

Presentation slides and white board.

### **Reading List:**

Required:

- Berk, DeMarzo (2014, 3/E): Corporate Finance
- Copeland, T. E./ Weston, J. F./ Shastri, K. (2005): Financial Theory and Corporate Policy, USA, Addison Wesley, 4th International Edition.

Further recommended readings will be given in the lecture.

### **Responsible for Module:**

Kaserer, Christoph; Prof. Dr. rer. pol. habil.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Corporate Finance (WI000091): Übung (Übung, 2 SWS)

Cehajic A

Corporate Finance (WI000091) (Vorlesung, 2 SWS)

Kaserer C ( Cehajic A )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI000285: Innovative Entrepreneurs - Leadership of High-Tech Companies | Innovative Unternehmer - Führung von High-Tech Unternehmen

Version of module description: Gültig ab summerterm 2021

|                                  |                             |                                  |                                             |
|----------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3            | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The grading is based on project work. Participants choose an individual challenge running over several weeks during the semester. Each student has to write a reflection paper (max. 1500 words) on their experiences during the project work.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Knowledge: No special requirements, willingness to participate
- Abilities: Identifying opportunities; proactiveness; communication; commitment
- Skills: openness; analytical thinking; visual thinking; self-motivation; networking

#### Content:

The objective of the module is to inspire and motivate the participants coming from various disciplines for an entrepreneurial career, and to give them a basic understanding about founding and managing technology- and growth-oriented companies. To serve this purpose, the module provides an introduction to the topic of (effectual) entrepreneurship, as well as guest lectures by outstanding founders, entrepreneurs, managers, and investors on selected topics, such as:

1. The entrepreneurial ecosystem
2. Founding of companies for students and scientists
3. How to develop an idea into a market-ready product
4. Financing of startups
5. Corporate growth
6. Creating and managing an entrepreneurial culture

7. Strategic business management
8. Innovation management
9. Corporate finance
10. Business succession

Moreover, for self-motivated participants, there is ample opportunity for personal development through interactive workshops, closed networking events.

### **Intended Learning Outcomes:**

Upon successful completion of this module, participants will be able

Upon successful completion of this module, participants will be able to...

- understand the entrepreneurial mindset
- recognize and develop personal strengths
- develop and implement personal ideas
- understand Design Thinking methodology

Moreover through guest speakers' lectures and optional workshops participants will be empowered to:

- realize opportunities and challenges associated with the founding and managing of technology- and growth-oriented companies;
- create a personal roadmap for entrepreneurial success.

Thus, students familiarize with topics like opportunity recognition, innovation management, growth, leadership, and the facets of entrepreneurship. In doing that, they are enabled to see, realize, and experience the multiplicity in the everyday life of an entrepreneur, entrepreneurial personalities, as well as entrepreneurial skills and motivations.

### **Teaching and Learning Methods:**

As guest lecturers, each week an outstanding founder, entrepreneur, manager, or investor, spanning a wide-ranging industrial spectrum, is hosted to report on their individual entrepreneurial careers.

At the end of each lecture, the participants can actively engage in discussions with the guest speaker during an open session.

Moreover, in context of a workshop, the participants venture their own personal qualities and skills to understand in a structured way their own entrepreneurial identity. In doing that, they focus on their individual strengths and resources to develop a plan to be entrepreneurial.

The module also provides participants with ample opportunity to network with people from the entrepreneurial environment of TUM.

### **Media:**

- Lecture slides downloadable

- Online discussion forum (e.g., for questions and feedback on guest lectures)
- Handouts (distributed online)

**Reading List:**

Read, S., Sarasvathy, S., Dew, N., Wiltbank, R., & Ohlsson, A. V. (2016). Effectual Entrepreneurship. Taylor & Francis

**Responsible for Module:**

Schönenberger, Helmut; Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Innovative Unternehmer - Führung von High-Tech Unternehmen (WI000285) (Vorlesung, 2 SWS)

Schönenberger H [L], Schönenberger H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI000286: Environmental and Natural Resource Economics | Environmental and Natural Resource Economics

Version of module description: Gültig ab summerterm 2017

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning success will be assessed by a written exam (120 minutes)..

By answering the questions students show that they are able to understand the economic view of environmental and resource problems. Furthermore students show that they are able to compare and evaluate alternative economic instruments (e.g. taxes, emission permits, payments for environmental services). They show their ability to apply environmental policy instruments and valuation methods to specific problems. Finally students demonstrate that they are able to conduct and interpret economic cost-benefit analyses.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

A basic knowledge in Microeconomic theory is recommended

#### Content:

- a) Economic growth and the environment
- b) Economic analysis of environmental problems
- c) Role of institutions and liability rules
- d) Analysis of environmental economic instruments
  - Command and control measures
  - Pollution taxes
  - Emission trading
  - Payments for environmental services
- e) Valuation methods for environmental goods
- f) Cost-benefit analysis.

**Intended Learning Outcomes:**

At the end of the module the students are able to understand the economic view of environmental and resource problems. They know alternative economic instruments, e.g. taxes, emission permits, payments for environmental services and how they work and are able to compare them regarding their economic efficiency. They know and can apply specific valuation methods to attach a monetary value to environmental effects and conduct and interpret economic cost-benefit analyses.

**Teaching and Learning Methods:**

The module will be held in the form of lectures which are partially combined with group discussions and exercises. The main learning objective is here to understand the economics of environmental policy. Lectures are a format suitable to convey theoretical knowledge about the welfare implications of policy interventions. Integrated exercises will help students to apply acquired knowledge to concrete problems and derive economically sound answers.

**Media:**

PowerPoint

**Reading List:**

A digital reader consisting of various textbook chapters and journal articles will be put on Moodle for each chapter of the course.

Jaeger, W.K. (2005): Environmental Economics. Island Press.

Mankiw, N.G. and M.P. Taylor (2011): Microeconomics. 2nd Edition. South Western.

Perman, R., Y. Ma, J. McGilvray, M. Common (2003): Natural Resource and Environmental Economics. 3rd Edition. Pearson Education Limited.

Tietenberg, T. and L. Lewis (2010): Environmental Economics & Policy. Prentice Hall.

**Responsible for Module:**

Glebe, Thilo; PD Dr. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Environmental and Natural Resource Economics (WI000286) (Vorlesung mit integrierten Übungen, 4 SWS)

Glebe T

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ1647: Remediation of Contaminated Sites - Lecture and Exercises | Altlastensanierung - Vorlesung und Übungen

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung besteht aus einer schriftlichen Klausur (120 min). Anhand der Klausur zeigen die Studierenden, dass sie gesetzliche Regelungen, die sich mit Altlasten beschäftigen, verstehen, das Gefährdungspotential einer Altlast im Hinblick auf die Art der Schadstoffe und den Emissionspfad bewerten können, die verschiedenen Untersuchungsmethoden verstehen sowie eine geeignete Probenahmestrategie und analytisches Untersuchungsprogramm bewerten können.

Das Modul "Altlastensanierung - Vorlesung und Übungen" ist das Alternativmodul zu "Altlastensanierung - Vorlesung und Seminar". Je nach verfügbaren Plätzen behält sich der Modulverantwortliche vor, die Studierenden dem einen oder anderen dieser beiden Module zuzuordnen. Es kann nur eines von beiden Modulen absolviert werden.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Einführung in die Bodenkunde 1 und 2 müssen erfolgreich absolviert sein (Ausschlusskriterium).

#### Content:

Vorlesung: Bundesbodenschutzgesetz, Vorgehensweise bei der Erkundung von Altlasten; branchentypische Kontaminationen (Altablagerungen - Altstandorte, Rüstungs- und Militäraltlasten); Bewertung von Kontaminanten (Hauptkontaminanten - Prioritätskontaminanten, Stofftransport, Exposition); Gefährdungspotential, ökotoxikologische Tests; Untersuchung von Altlasten (Untersuchungsmethoden, Probenahmestrategie, analytisches Untersuchungsprogramm); Sanierungsziele; Sicherungsmaßnahmen; Dekontaminationsverfahren; Rekultivierung und Renaturierung (Böden auf Altstandorten, Bergbaufolgelandschaften).



Übungen: Besuch von Altlastenbetrieben im Raum München: Biologische ex-situ Sanierung organisch belasteter Böden; Beprobung kontaminierten Bodenmaterials in Haufwerken; Immissionsschutzvorgaben für altlastenbearbeitende Betriebe; Sortierung und (Zwischen-) Lagerung kontaminierter Böden vor der Entsorgung in geeigneten Deponien; LAGA Deponieklassen zur Klassifikation kontaminierter Böden; Verwertungsmöglichkeiten für kontaminiertes Material; innovative in-situ Sanierungs- und Sicherungsmaßnahmen; Verhältnis von Investitions- und Betriebskosten bei langfristigen Sanierungsmassnahmen; Sicherungsmaßnahmen in Bergbaufolgelandschaften; spezifische Probleme in Braunkohlentagebaufolgelandschaften; Evaluation von Rekultivierungs- und Renaturierungsmaßnahmen; gesetzliche Hintergründe: Bundesbodenschutz-, Kreislaufwirtschafts- und Wasserschutzrecht.

### **Intended Learning Outcomes:**

Nach erfolgreicher Teilnahme an den Modulveranstaltungen sind die Studierenden in der Lage, gesetzliche Regelungen, die sich mit Altlasten beschäftigen, zu verstehen, die richtige Vorgehensweise bei der Untersuchung von Altlasten und Altlastenverdachtsflächen sowie bei der Sanierung von Altlasten anzuwenden, das Gefährdungspotential einer Altlast im Hinblick auf die Art der Schadstoffe und den Emissionspfad zu bewerten, die verschiedenen Untersuchungsmethoden zu verstehen sowie eine geeignete Probenahmestrategie und analytisches Untersuchungsprogramm zu bewerten, unterschiedliche Sanierungstechniken und Rekultivierungsmaßnahmen zu bewerten und in Abhängigkeit von der jeweiligen Altlast die geeignete anzuwenden. Zudem sind die Studierenden in der Lage, verschiedene altlastenbearbeitende Betriebe und Altlastenstandorte zu bewerten sowie die angewandten Sanierungsverfahren kritisch, im Hinblick auf Sanierungserfolge und Umweltauswirkungen, zu analysieren.

### **Teaching and Learning Methods:**

Das Modul besteht aus einer Vorlesung und einer Übung. In der Vorlesung werden den Studierenden die gesetzliche Regelungen, die sich mit Altlasten beschäftigen, die richtige Vorgehensweise bei der Untersuchung von Altlasten und Altlastenverdachtsflächen sowie bei der Sanierung von Altlasten, das Gefährdungspotential einer Altlast im Hinblick auf die Art der Schadstoffe und den Emissionspfad, die verschiedenen Untersuchungsmethoden sowie eine geeignete Probenahmestrategie und analytisches Untersuchungsprogramm, unterschiedliche Sanierungstechniken und Rekultivierungsmaßnahmen vermittelt.

In den Übungen wird mit den Studierenden während des Besuchs ausgewählter belasteter Standorte und Sanierungseinrichtungen verschiedene altlastenbearbeitende Betriebe und Altlastenstandorte bewertet sowie die angewandten Sanierungsverfahren kritisch, im Hinblick auf Sanierungserfolge und Umweltauswirkungen, analysiert.

### **Media:**

Präsentationen

**Reading List:**

Präsentationen; vertiefende Bücherliste auf Anfrage

**Responsible for Module:**

Kögel-Knabner, Ingrid; Prof. Dr. rer. nat. Dr. rer. nat. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Remediation of Contaminated Sites - Regeneration of contaminated soils (Vorlesung, 2 SWS)

Bucka F

Altlastensanierung - Kontaminierte und rekultivierte Böden (Übung, 2,1 SWS)

Bucka F, Heister K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ4206: Material Flow Management and Applications | Material Flow Management and Applications

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>105  | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a research paper of around 12-15 pages which is the means to evaluate whether the students have understood and whether they are able to apply the methodology of material flow management on a case study in a scientifically manner and to create an own scientific paper about concepts for material flow management and treatment of materials based on the methodologies of material flow analysis and life cycle assessment. management and treatment of materials based on the methodologies of material flow analysis and life cycle assessment.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

knowledge in natural science (biology, chemistry, ecology, physics);  
understanding for engineering science and also for social/cultural aspects.

#### Content:

The students acquire detailed and differentiated knowledge about the following topics:

- need of material flow management
- procedure of material flow management
- material and substance flow analysis
- material flow assessment by sustainability indicators
- life cycle assessment
- development of strategies and measures for material flow management  
(e.g. resource efficiency, urban mining, industrial ecology, bio-economy, circular economy).

**Intended Learning Outcomes:**

By the means of the module the students are able to:

- understand the necessity of material flow management
- understand the relationships between different processes, technological treatments of materials and organizational measures
- apply the procedure of material and substance flow analysis
- apply the assessment methods of indicator systems and life cycle assessment
- create concepts for material flow management and treatment of materials.

**Teaching and Learning Methods:**

Concerning teaching methods, lecture and presentation parts provide the theoretical foundation of materials flow management. Real case studies are introduced to the students and worked out in the class. Likewise within interdisciplinary projects in reality, the students have to define and to solve problems collaboratively in group work by studying specialist literature and data sources. At the end they have to create a research paper as homework about this topic. The students are supervised by tutorials by the lecturer.

**Media:**

Power point presentation, lecture sheets, case studies of material and substance flow analysis and life cycle assessment.

**Reading List:**

Brunner, P.H., Rechberger H. (2004): Practical Handbook in Material Flow Analysis. Advanced Methods in Resource and Waste Management. Lewis Publishers, Boca Raton, pp. 318.  
Brunner, P.H.; Rechberger, H.; 2016: Handbook of Material Flow Analysis: For Environmental, Resource, and Waste Engineers. Taylor & Francis Inc; 2. Revised Edition, pp. 453  
Weber-Blaschke, G.; 2009: Stoffstrommanagement als Instrument nachhaltiger Bewirtschaftung natürlicher und technischer Systeme. Ein kritischer Vergleich ausgewählter Beispiele. Schriftenreihe „Nachwachsende Rohstoffe in Forschung und Praxis“ des Wissenschaftszentrums Straubing, Bd. 1, Verlag Attenkofer, Straubing, 330 S.

**Responsible for Module:**

Prof. Dr. Gabriele Weber-Blaschke - Lehrstuhl für Holzwissenschaft Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising; 08161/71- 5635; weber-blaschke@hfm.tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Material Flow Management and Application (Vorlesung, 3 SWS)

Weber-Blaschke G [L], Weber-Blaschke G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ6339: Applied River Restoration | Angewandte Fließgewässerrenaturierung

Version of module description: Gültig ab summerterm 2012

|                       |                     |                          |                       |
|-----------------------|---------------------|--------------------------|-----------------------|
| <b>Module Level:</b>  | <b>Language:</b>    | <b>Duration:</b>         | <b>Frequency:</b>     |
| <b>Credits:*</b><br>3 | <b>Total Hours:</b> | <b>Self-study Hours:</b> | <b>Contact Hours:</b> |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

#### Intended Learning Outcomes:

#### Teaching and Learning Methods:

#### Media:

#### Reading List:

#### Responsible for Module:

**Courses (Type of course, Weekly hours per semester), Instructor:**

Applied River Restoration (Vorlesung, 2 SWS)

Geist J [L], Pander J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ6332: Soils of the World: Properties and Protection | Böden der Welt: Eigenschaften und Schutz

Version of module description: Gültig ab winterterm 2014/15

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung erfolgt in Form einer mündlichen Prüfung (25 min). Anhand der Prüfung zeigen die Studierenden, dass sie sämtliche Bodentypen der Erde mit ihren wichtigsten Eigenschaften kennen und ihre Genese und die Gründe für ihr Auftreten in den verschiedensten Teilen der Welt verstehen. Sie zeigen zudem, dass sie die Zusammenhänge zwischen der natürlichen Boden(un)fruchtbarkeit und der Gefährdung der Böden durch Landnutzung verstehen und Produktionsmöglichkeiten auf Standorten unterschiedlicher Fruchtbarkeit und deren geschichtliche und kulturelle Implikationen kennen. Sie zeigen, dass sie in der Lage sind, die spezifischen Erfordernisse bei der Nutzung verschiedener marginaler Standorte zu beurteilen. Zudem zeigen sie, dass sie die Möglichkeiten des Bodenschutzes durch den Einsatz von Bäumen kennen.

#### Repeat Examination:

Next semester / End of Semester

#### (Recommended) Prerequisites:

Einführung in die Bodenkunde 1 und 2 müssen erfolgreich absolviert sein (Ausschlusskriterium).

#### Content:

1. Eigenschaften, Verbreitung, Genese und Nutzungsmöglichkeiten sämtlicher Bodentypen der Erde, dargestellt gemäß der internationalen Bodenklassifikation WRB. 2. Das Welternährungsproblem, was ist Bodendegradation?, Steigerung der Nahrungsmittelproduktion auf fruchtbaren Standorten, marginale Standorte (stark erosionsgefährdet, semiarid, stark verwittert), Agroforstwirtschaft (Definitionen, Effekte von Bäumen auf den Boden, Erosionsschutz, Wasserhaushalt, Nährstoffhaushalt, die Rolle der Wurzeln).

**Intended Learning Outcomes:**

Die Studierenden kennen sämtliche Bodentypen der Erde mit ihren wichtigsten Eigenschaften. Sie haben ihre Genese und die Gründe für ihr Auftreten in den verschiedensten Teilen der Welt verstanden. Die Studierenden verstehen die Zusammenhänge zwischen der natürlichen Boden(un)fruchtbarkeit und der Gefährdung der Böden durch Landnutzung. Sie kennen die Produktionsmöglichkeiten auf Standorten unterschiedlicher Fruchtbarkeit und deren geschichtliche und kulturelle Implikationen. Sie sind in der Lage, die spezifischen Erfordernisse bei der Nutzung verschiedener marginaler Standorte zu beurteilen. Sie kennen die Möglichkeiten des Bodenschutzes durch den Einsatz von Bäumen.

**Teaching and Learning Methods:**

Das Modul besteht aus zwei Vorlesungen. Anhand der Vorlesungen werden den Studierenden sämtliche Bodentypen der Erde mit ihren wichtigsten Eigenschaften, ihre Genese und die Gründe für ihr Auftreten in den verschiedensten Teilen der Welt, Zusammenhänge zwischen der natürlichen Boden(un)fruchtbarkeit und der Gefährdung der Böden durch Landnutzung, die Produktionsmöglichkeiten auf Standorten unterschiedlicher Fruchtbarkeit und deren geschichtliche und kulturelle Implikationen sowie die Möglichkeiten des Bodenschutzes durch den Einsatz von Bäumen in Form von Präsentationen vorgestellt.

Anhand von Beispielen lernen die Studierenden die spezifischen Erfordernisse bei der Nutzung verschiedener marginaler Standorte zu beurteilen.

**Media:**

Präsentationen, Tafelanschriebe

**Reading List:**

1. IUSS Working Group WRB (2015): World Reference Base for Soil Resources. World Soil Resources Reports 106 FAO, Rom.
2. Zech, W., Schad, P., Hintermaier-Erhard, G. (2014): Böden der Welt. Ein Bildatlas. Spektrum-Verlag, Heidelberg.
3. Blanco, H., Lal, R. (2008): Principles of soil conservation and management.
4. Diamond, J. (2005): Collapse: How societies choose to fail or survive (auch auf deutsch)

**Responsible for Module:**

Peter Schad (schad@wzw.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Bodendegradation und Bodenschutz in den Tropen und Subtropen (Vorlesung, 2 SWS)  
Schad P

Böden der Welt (Vorlesung, 2 SWS)  
Schad P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### AR30055: Automation & Robotics in Construction | Automatisierung und Robotik im Bauwesen [ARC]

Version of module description: Gültig ab winterterm 2019/20

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is carried out as part of a scientific assignment. The exam consists of a final presentation of the scientific findings followed by an oral exam (50% of the final grade) and a scientific report (50% of the final grade) at the end of the semester.

The final presentation and scientific report will refine students' skills in developing solution-based approaches, transferring acquired knowledge to case studies related to practice, and communicating the results to the public.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

no specific previous knowledge required

#### Content:

In this module the following topics will be taught:

- Prefabrication of linear, 2-dimensional and 3-dimensional products and elements;
- Industrialized manufacturing for the production of steel frames and space frames; wood and timber frames and space frames; precast concrete columns, beams, girders, elements and spatial units; masonry wall, floor and roof elements;
- Basics of flexible manufacturing systems;
- Assembly process and quick connect systems for on-site construction;
- Systematic and prefabricated installation systems;
- Zero-waste factories in Japan;
- Systematic disassembly: reverse logistics, re-customization;

- Logistics, on-site/off-site process control;
- Industrial construction logistics for Land, Sea, & Air;
- Logistics and ICT-based enterprise resource planning;
- Innovative methods for construction logistics (e.g. RFID);
- Overview of construction automation and robotics systems (on-site);
- Automated and robotic construction systems;
- Automated sites, systems and typologies;
- Modular production systems;
- Human-machine cooperation onsite, Exoskeleton-systems; Sustainable sites;
- Automated deconstruction, urban mining, and recycling.

### **Intended Learning Outcomes:**

After successfully participating in the module, students are able to:

- differentiate between different building system typologies as well as related manufacturing technologies and manufacturing processes,
- determine and analyze the efficiency potential of different strategies,
- understand and adapt the importance of robotics and automation for customer integration and customization in industrial construction,
- independently develop innovative applications for the use of automation / robotics for more sustainable construction processes,
- present their own solutions in front of a critical audience, defend their results and solutions in a Q&A session and write a scientific report.

### **Teaching and Learning Methods:**

The module will be held in the form of lectures and seminars. The lectures will discuss fundamentals about robotic construction processes. The seminar will focus on current practice-oriented case studies in which students will be able to apply the acquired knowledge in group work and develop their own solution approaches. The group work offers the students the opportunity to actively participate in the development of project-related topics, discuss their idea with their peers. The group work requires regular attendance to discuss the intermediate results with the supervising lecturer. The results will be both presented in a final presentation and written in a scientific report at the end of the semester.

### **Media:**

Presentations, videos, handouts, onsite excursions if required

### **Reading List:**

A literature list will be made available to the students at the beginning of the module.

### **Responsible for Module:**

Bock, Thomas

**Courses (Type of course, Weekly hours per semester), Instructor:**

Automatisierung und Robotik im Bauwesen (Seminar, 4 SWS)

Bock T, Iturralde Lerchundi K, Pan W

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ6415: Applied Limnology | Angewandte Limnologie (V+Ü)

Version of module description: Gültig ab winterterm 2018/19

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150         | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination is an oral examination (30 min).

In the examination the students show that they can independently evaluate unknown waters and, if necessary, develop approaches for the restoration or rehabilitation of the water bodies.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The module General Limnology is recommended.

#### Content:

The module includes the following contents:

The eutrophication of water bodies: historical development, causes, biological consequences, extent, prevention; methods of water body qualification: Vollenweider model, chemical, physical and biological models; water body restoration, fall axe games, water body aeration, P-precipitation, sediment conditioning, biomanipulation, water body acidification: history, extent, chemical and biological consequences, countermeasures, practical introduction to bioindication with macrophytes, application of the macrophyte index for the assessment of running waters and lakes.

#### Intended Learning Outcomes:

After successful participation in the module event, students are able to independently evaluate unknown waters and, if necessary, develop approaches for the restoration or rehabilitation of the water bodies.

#### Teaching and Learning Methods:

The module consists of a lecture and an exercise. In the lecture the necessary basics from different areas of applied limnology are presented. In the exercise the theoretical basics are deepened in

cooperation with other students by applying the macrophyte index to evaluate different types of water bodies.

**Media:**

Power-Point, Flipchart, Tafelarbeit, Digitale Mikrophotographie

**Reading List:**

Will be announced in the courses

**Responsible for Module:**

Uta Raeder ([uta.raeder@wzw.tum.de](mailto:uta.raeder@wzw.tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Angewandte Limnologie (Vorlesung, 1 SWS)

Raeder U, Hoffmann M

Makrophyten als Bioindikatoren zur Bewertung der Wasserqualität II (Übung, Limnologie) (Übung, 3 SWS)

Zimmermann S, Hoffmann M, Raeder U

Makrophyten als Bioindikatoren zur Bewertung der Wasserqualität I (Übung, Limnologie) (Übung, 3 SWS)

Zimmermann S, Hoffmann M, Raeder U

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU900011: Partner University - Elective Module | Partneruniversität - Wahlmodul

Version of module description: Gültig ab summerterm 2013

|                      |                     |                          |                       |
|----------------------|---------------------|--------------------------|-----------------------|
| <b>Module Level:</b> | <b>Language:</b>    | <b>Duration:</b>         | <b>Frequency:</b>     |
| <b>Credits:*</b>     | <b>Total Hours:</b> | <b>Self-study Hours:</b> | <b>Contact Hours:</b> |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

#### Intended Learning Outcomes:

#### Teaching and Learning Methods:

#### Media:

#### Reading List:

#### Responsible for Module:

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ2469: Limnology of Running Waters | Limnologie der Fließgewässer

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is an oral examination (30 min). By means of the examination, students show that they can typify and evaluate the quality of unknown watercourses by means of measurement results of physical and chemical conditions as well as by the mapped flora and fauna. The students show that they are able to assess the ecological status of a watercourse based on the EU Water Framework Directive and develop development plans for running waters.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The module 'General Limnology' is recommended.

#### Content:

The module includes the following contents:

1. physical-chemical conditions: Temperature, flow, boundary layer phenomena, substrate distribution, oxygen, hydrocarbon, nutrients.
2. biological conditions: Epiphytes, macrophytes, plankton, consumers, macroinvertebrates, fish.
3. colonization of the three riverine habitats: pelagial, benthal, hyporheic interstitial.
4. adaptation strategies and developmental biology of running water organisms, river typology, saprobity and trophy in running waters, River Continuum Concept.
5. practical exercises, hydrophysical measurements, hydrochemical analyses, mapping of flora and fauna, application of biological indices, river structure quality mapping.

#### Intended Learning Outcomes:

After successful participation in the module course, the students are able to typify and evaluate the quality of unknown watercourses by means of independent measurements of physical and chemical conditions as well as by mapping the flora and fauna. The students are able to assess



the ecological status of a water body according to the EU Water Framework Directive and to develop development plans for running waters.

**Teaching and Learning Methods:**

The module consists of a lecture and an exercise. In the lecture the necessary basics from different areas of stream limnology are taught. In the exercise the theoretical basics for the evaluation of rivers and streams are deepened in cooperation with other students by applying different physical and chemical methods and biological indices.

**Media:**

PowerPoint, flipchart, blackboard work, digital microphotography

**Reading List:**

Introduction to Limnology, Schwoerbel; Running water biology

**Responsible for Module:**

Uta Raeder (uta.raeder@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Vorlesung Limnologie der Fließgewässer (Vorlesung, 1 SWS)

Raeder U

Limnologie der Flüsse und Bäche (Übung) I (Übung, 3 SWS)

Raeder U, Hoffmann M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ6115: Environmental Law | Planungsbezogenes Umweltrecht

Version of module description: Gültig ab winterterm 2020/21

|                                         |                            |                                  |                                      |
|-----------------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Aufgrund des Pandemiegeschehens hat der/die Studierende auch die Möglichkeit, an einer beaufsichtigten elektronischen schriftlichen Fernprüfung (Aufsicht mit Proctorio, 60 min.) teilzunehmen (Onlineprüfung: WZ6115o).

Diese schriftliche Prüfung wird zeitgleich parallel in Präsenz angeboten (WZ6115).

Die Modulprüfung erfolgt in Form einer Klausur (60 min). Anhand der Klausur zeigen die Studierenden, dass sie die Struktur und Zusammenhänge des Umweltrechts verstehen. Sie zeigen zudem, dass sie rechtlich relevante Fragestellungen erkennen und jedenfalls grundsätzlich auch sachgerecht beantworten können.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Der vorherige Besuch der Vorlesung "Öffentliches Bau- und Planungsrecht" wird empfohlen, ist aber nicht zwingend erforderlich

#### Content:

Regelungsgegenstände des Umweltrechts

Naturschutzrecht

" Landschaftsplanung

" Schutzgebiete

" Naturschutzrechtliche Eingriffsregelung

" Artenschutzrecht

" FFH- und Vogelschutzgebiete

Immissionsschutzrecht

" Genehmigungsverfahren  
" Genehmigungsvoraussetzungen  
Umweltverträglichkeitsprüfung  
Wasserrecht

**Intended Learning Outcomes:**

Nach der Teilnahme an der Vorlesung verstehen die Studierenden die Struktur und Zusammenhänge des Umweltrechts. Sie sind zudem in der Lage, rechtlich relevante Fragestellungen zu erkennen und jedenfalls grundsätzlich auch sachgerecht zu beantworten. Sie sind in der Lage, bei einem konkreten Projekt sowohl mit weiteren Planern als auch und insbesondere mit juristischen Beratern des Bauherrn qualifiziert zusammenzuarbeiten.

**Teaching and Learning Methods:**

Das Modul besteht aus einer Vorlesung. In der Vorlesung werden den Studierenden die Struktur und Zusammenhänge des Umweltrechts sowie rechtlich relevante Fragestellungen vorgestellt und anhand von Auseinandersetzungen mit Gesetzestexten und Fallbeispielen veranschaulicht.

**Media:**

**Reading List:**

Bundesnaturschutzgesetz; Bundes-Immissionsschutzgesetz; Gesetz über die Umweltverträglichkeitsprüfung; Wasserhaushaltsgesetz

**Responsible for Module:**

Kuchler, Ferdinand; Prof. Dr. jur.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Planungsbezogenes Umweltrecht (Vorlesung, 2 SWS)

Pauleit S [L], Loscher T, Pauleit S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ1561: Value Chain Economics | Value Chain Economics

Version of module description: Gültig ab winterterm 2014/15

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of two presentations per group and a final written report (15 to 20 pages) per group. Each of the two presentations lasts 30 minutes and is followed by a 30-minute questions-and-answers session. The presentations take place throughout the semester during class time. The final written report is due at the end of the semester. Students summarize the content of their presentations and incorporate the feedback and information received during the questions-and-answers sessions in the final report.

The presentation tests the ability of students to (1) describe in oral form the main actors, their interactions and the structure of value chain(s), and the institutional environment (including industrial policies); (2) explain in oral form the performance of the chain(s), the distribution of welfare, the effect of the institutional environment on the chain's performance of the chain by applying economic models and conceptual frameworks; (3) explain in oral form potential challenges for the functioning and performance of the chain(s) and related market-based and non-market based solutions by applying economic models and conceptual frameworks.

The final paper tests the ability of students to (1) describe in written form the main actors, their interactions and the structure of the value chain(s), and the institutional environment (including industrial policies); (2) explain in written form the performance of the chain(s), the distribution of welfare, the effect of the institutional environment on the chain's performance by economic models and conceptual frameworks; (3) explain in written form potential challenges for the functioning and performance of the value chain(s) and suitable market-based and non-market based solutions to improve the performance of the chain(s) and related solutions by applying economic models and conceptual frameworks; (4) draw conclusions regarding the analysis of the value chain(s) performed throughout the semester.

Each presentation contributes 30% to the final grade. The final report contributes 40% of the final grade.

Each student in a group is responsible for one part of the presentation. Individualized grades for each group presentation are obtained as follows:

- 10% Organization and structure
- 20% Quality of content and originality
- 10% Clarity of exposition of the student
- 60% Ability of the student to address questions

All students in a group contribute to the drafting of the final report. The final report is structured in sections as listed below. Each section contributes to the grade for the final report with a given % weight as explained below. The final report sections and respective weights are as follows:

- Abstract, Introduction (10%)
- Value chain structure and institutional environment (20%)
- Challenges (20%)
- Proposed solutions (20%)
- Conclusions (20%)
- References (10%)

Each section of the report is graded as follows:

- 25% Organization and structure
- 25% Language quality
- 50% Quality of content and originality

For each section, the group clearly indicates the extent (in %) of each student's contribution. Individual grades for the final report are obtained by weighting the performance in each section by the student's contribution and summing up the partial grade for each section of the final report.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

Undergraduate level microeconomics and industrial organization.

**Content:**

The course covers the economics of value chains with a focus the agro-food sector.

The course provides an overview of the institutional framework in which the EU agro-food sector operates, and covers trends in and challenges to the functioning and performance of the agro-food sectors in the EU, USA and developing countries. The course covers economic models and conceptual frameworks required to analyse the economic effects of various challenges posed by globalization, climate change, growing consumer demand for quality and sustainable products, market power and the imbalance of power within the supply chain. The course introduces students to the EU industrial policy for the agro-food sector and discusses market-based and non-market based solutions to improve the functioning and performance of the agro-food sector, including food

labelling and production, processing, and distribution standards, formal and informal coordination and alignment of incentives among different actors of the supply chain.

**Intended Learning Outcomes:**

After successfully completing the module, students will be able to perform an independent analysis of a value chain. This entails being able to:

- (1) describe the main actors, their interactions and the structure of the value chain
- (2) describe the institutional environment and the relevant industrial policies
- (3) assess the performance of the value chain and the distribution of generated welfare along the value chain by applying economic models and conceptual frameworks
- (4) assess the effect of the institutional environment (including industrial policies) on the functioning and performance of the value chain by applying economic models and conceptual frameworks
- (5) find suitable market-based and non-market based solutions to improve the functioning and performance of the value chain by applying economic models and conceptual frameworks
- (6) present in oral form the analysis of a value chain
- (7) draw up a written report of the analysis of a value chain

**Teaching and Learning Methods:**

(2 SWS lecture) Lectures are used to provide an overview of the institutional framework, trends and challenges faced by the agro-food sector and to cover the economic models and conceptual frameworks needed to analyse value chains. Frontal lectures are used to provide students with the needed background for the analysis of value chain(s).

(1 SWS exercise) Market experiments (e.g., the-market-for-lemons-class-experiment) are used to illustrate economic models and conceptual frameworks. Group work is used to train students to research and summarize information related to value chain(s) and their institutional environment, to assess the performance of value chain(s), to explain challenges to the functioning and performance of value chain(s), to find potential solutions, and to draw up a final report.

(1 SWS seminar) Student presentations and class discussion are used to train students to present their analysis in oral form and to receive and integrate feedback into a written report.

**Media:**

Teaching aids include: PowerPoint slides, scientific journal papers and hand-outs.

**Reading List:**

Due to the lack of a standardized textbook on the specific subject, scientific journal articles from the recent literature and official reports from public institutions (e.g., EU, USDA etc.) will be provided during the lecture.

**Responsible for Module:**

Luisa Menapace [luisa.menapace@tum.de](mailto:luisa.menapace@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Value Chain Economics (WZ1561) (Vorlesung mit integrierten Übungen, 4 SWS)

Menapace L [L], Ola O

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ4198: Wildlife Management and Wildlife-Human Interactions | Wildlife Management and Wildlife-Human Interactions

Version of module description: Gültig ab winterterm 2015/16

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Written assignment (ca. 15 pages) requiring review of literature, synthesis and integration of key concepts and findings from the literature to develop a coherent research proposal that clearly demonstrates knowledge in the field of species management and conservation strategies and of human dimensions as a research and applied field of study. Expected to read in advance where possible assigned readings so to be prepared for course lectures.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

None

#### Content:

This lecture combines contents of Wildlife Management and Wildlife Human Interactions. The key aspects are: 1) Principles of Wildlife Management & Wildlife Science, 2) Planning tools, 3) Case study: Strategic planning, 4) Conflicting views in WMT with case studies, 5) Basic Concepts in Ecology, 6) Reintroductions studies, 7) Global threats to Conservation, 8) Nature of human dimensions (HD) from a research perspective through various examples 9) Nature of various wildlife-human interactions from different perspectives, 10) Nature of public involvement and HD as an applied approach 11) Types of conflict, levels of planning and how to work with people toward solutions, 12) Understanding decision-making processes.

#### Intended Learning Outcomes:

After the course students are able to: understand important ecological concepts in wildlife management; understand the importance of the human dimension in wildlife management; analyse a conservation strategy for a species; apply wildlife management plans; evaluate species



and protected area management plans; understand the importance and nature of objectivity in conducting research and being a human dimension researcher; develop the ability to synthesize relevant literature pertinent to a research problem; organize ideas effectively and communicate these in a well-organized and developed written proposal.

**Teaching and Learning Methods:**

Lecture, video, group exercises, discussions

**Media:**

lecture notes, flip-chart/board, hand-outs, additional reading material

**Reading List:**

Sinclair et al. 2006, Wildlife Ecology, Conservation, and Management, ISBN 1-4051-0737-5 ;  
Krausman 2002, Wildlife Management, ISBN 0-1328-0850-1; Pullin 2002, Conservation Biology, ISBN 0-521-64482-8

**Responsible for Module:**

Kühn, Ralph; Apl. Prof. Dr. agr. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Wildlife-Human Interactions (Seminar, 2 SWS)

Kühn R [L], Bath A

Wildlife Management (Vorlesung, 2 SWS)

Kühn R [L], Rödl T

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI000021: Economics I - Microeconomics | Volkswirtschaftslehre I - Mikroökonomie [ECON 1]

#### *Microeconomics*

Version of module description: Gültig ab summerterm 2021

|                                  |                                    |                                  |                                      |
|----------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6            | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

In the exam (written, 120 minutes) students should demonstrate their ability to adequately interpret the microeconomic concepts and apply the methods worked on in class, in limited time and without aid. By means of multiple-choice-questions, which are either embedded in a context/case/scenario or require prior computation, students' capacity to apply the learned solution strategies to new settings and draw correct economic implications is assessed.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

None

#### **Content:**

This course provides an introduction to basic concepts of microeconomics. It deals with the behaviour of individual economic units, such as households, business firms, and public institutions. Another concern is how these units interact to form markets and industries. How can consumer decisions be explained and how can aggregate demand be derived from consumer choice? Which are the factors that determine the production decisions of companies? How do equilibrium prices emerge in competitive markets, how in monopoly markets? What is the effect of government interventions in markets (e.g. taxes, price controls)? How does market power affect social welfare? Which factors lead to market failure?

#### **Intended Learning Outcomes:**

After attending this module, students will be able to describe economic tradeoffs (particularly in choice under scarcity situations of consumers and firms). Moreover, they know strategies to solve

those tradeoffs and are capable of applying them to new situations. Students are able to explain the fundamental economic mechanisms underlying specialisation and trade (particularly in view of technological progress). Students can predict how government interventions (e.g. taxes, price controls) will affect simple competitive markets. They are able to explain why certain industries are prone to market concentration and how market power affects social welfare. They can distinguish which types of goods are efficiently provided on free markets, and which not.

### **Teaching and Learning Methods:**

An interactive lecture introduces essential microeconomic concepts and theories and illustrates them with the help of topical empirical examples. Classroom experiments complement the classic bird-eye's perspective by nudging students to put themselves in the position of particular economic players, thereby requiring them to actively reflect the concepts introduced. Online surveys at the end of each chapter enable students to select which topics they would like to intensify in subsequent classes. In the accompanying exercise class, students practice, on specific problems and examples, the mathematical techniques needed to develop a deeper understanding of the economic concepts. In self-study students use the textbook to repeat the concepts introduced in class and apply them to additional examples.

This module is also offered at TUM Campus Straubing.

### **Media:**

Textbook, slides, exercise sheets, classroom experiments, online surveys

### **Reading List:**

Robert S. Pindyck and David L. Rubinfeld, Microeconomics, 8th Edition, Pearson, 2013 (ISBN 13: 978-0-13-285712-3). AND Robert S. Pindyck und David L. Rubinfeld, Mikroökonomie, 8. Aufl., Pearson Studium, 2013 (ISBN-13: 978-3868941678).

### **Responsible for Module:**

Kurschilgen, Michael; Prof. Dr. rer. pol.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Economics I - Übung am Campus Straubing (Übung, 2 SWS)  
Drobner C, Goerg S

Economics I - Übung am Campus Straubing (Übung, 2 SWS)  
Drobner C, Goerg S

Economics I am Campus Straubing (Microeconomics) (Vorlesung, 2 SWS)  
Goerg S

Economics I am Campus Straubing (Microeconomics) (Vorlesung, 2 SWS)  
Goerg S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI000021\_E: Economics I - Microeconomics | Economics I - Microeconomics [ECON 1]

#### Microeconomics

Version of module description: Gültig ab summerterm 2021

|                                  |                             |                                  |                                      |
|----------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6            | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In the exam (written, 120 minutes) students should demonstrate their ability to adequately interpret the microeconomic concepts and apply the methods worked on in class, in limited time and without aid. By means of multiple-choice-questions, which are either embedded in a context/case/scenario or require prior computation, students' capacity to apply the learned solution strategies to new settings and draw correct economic implications is assessed.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

None

#### Content:

This module provides an introduction to basic concepts of microeconomics. It deals with the behaviour of individual economic units, such as households, business firms, and public institutions. Another concern is how these units interact to form markets and industries. How can consumer decisions be explained and how can aggregate demand be derived from consumer choice? Which are the factors that determine the production decisions of companies? How do equilibrium prices emerge in competitive markets, how in monopoly markets? What is the effect of government interventions in markets (e.g. taxes, price controls)? How does market power affect social welfare? Which factors lead to market failure?

#### Intended Learning Outcomes:

After attending this module, students will be able to describe economic tradeoffs (particularly in choice under scarcity situations of consumers and firms). Moreover, they know strategies to solve

those tradeoffs and are capable of applying them to new situations. Students are able to explain the fundamental economic mechanisms underlying specialisation and trade (particularly in view of technological progress). Students can predict how government interventions (e.g. taxes, price controls) will affect simple competitive markets. They are able to explain why certain industries are prone to market concentration and how market power affects social welfare. They can distinguish which types of goods are efficiently provided on free markets, and which not.

### **Teaching and Learning Methods:**

An interactive lecture introduces essential microeconomic concepts and theories and illustrates them with the help of topical empirical examples. Classroom experiments complement the classic bird-eye's perspective by nudging students to put themselves in the position of particular economic players, thereby requiring them to actively reflect the concepts introduced. Online surveys at the end of each chapter enable students to select which topics they would like to intensify in subsequent classes. In the accompanying exercise class, students practice, on specific problems and examples, the mathematical techniques needed to develop a deeper understanding of the economic concepts. In self-study students use the textbook to repeat the concepts introduced in class and apply them to additional examples.

### **Media:**

Textbook, slides, exercise sheets, classroom experiments, online surveys

### **Reading List:**

Robert S. Pindyck and David L. Rubinfeld, Microeconomics, 8th Edition, Pearson, 2013 (ISBN 13: 978-0-13-285712-3). AND Robert S. Pindyck und David L. Rubinfeld, Mikroökonomie, 8. Aufl., Pearson Studium, 2013 (ISBN-13: 978-3868941678).

### **Responsible for Module:**

Kurschilgen, Michael; Prof. Dr. rer. pol.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Economics I (WI000021\_E) - English (Microeconomics) (Vorlesung, 2 SWS)  
Christoph D, Kurschilgen M

Economics I Exercise - English (WI000021\_E): (BSc English Track) (Übung, 2 SWS)  
Kurschilgen M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI000023: Economics II - Macroeconomics | Volkswirtschaftslehre II - Makroökonomie [VWL 2]

*Macroeconomics*

Version of module description: Gültig ab summerterm 2021

|                                  |                            |                                  |                                      |
|----------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6            | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam will be an E-test in Moodle without supervision at the end of the term. The test is designed to assess the participants' capabilities to apply macroeconomic theory in order to discuss and solve real world problems of the economy as a whole. Participants should demonstrate their capacity for abstraction (thinking in economic models), concretization (calculating, interpreting and applying the results of the model, mathematical processing as well as graphical illustration.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

no specific prerequisites

#### Content:

This module provides an introduction to basic concepts of macroeconomics. It covers:

- key institutions of capitalism as an economic system (private property, firms, markets)
- technological change as a trigger for economic growth
- price-taking and competitive markets
- price-setting, rent-seeking and market disequilibrium
- market successes and failures
- markets, contracts and information
- credit, banks and money
- economic fluctuations and unemployment
- unemployment, inflation, fiscal and monetary policy
- technological progress and living standards
- the Great Depression, the golden age of capitalism and the global financial crisis

**Intended Learning Outcomes:**

After attending the module, students will be able to describe the composition and distribution of the Gross Domestic Product. They can analyze the economic mechanisms underlying unemployment as well as issues regarding monetary policy and inflation. Further, participants will learn to understand the economic crisis and the wealth differences among nations. Students are enabled to think in models and apply mathematical solutions when approaching economic problems.

**Teaching and Learning Methods:**

The module consists of a lecture and an exercise course. The lecture content will be delivered in a verbal presentation with the help of slides. Since the foundation of the lecture is a textbook including recent economic history, the teaching is full of real life examples. The content of the lecture is put into practice in the exercise course which applies the theoretical knowledge by basic mathematical calculations and graphical illustrations. Therefore, the module aims at encouraging participants to independently think about economic problems discussed in the lecture and in the current literature. Students are enabled to use the instruments (abstract and model thinking) for operationalizing economic problems and solve them in the conventional, mathematical manner.

This module is also offered at TUM Campus Straubing.

**Media:**

<http://www.core-econ.org/>

**Reading List:**

The CORE Project (2016): 'The Economy', in: Azm Premji University, Friends Provident Foundation, HM Treasury, Institute for New Economic Thinking, Open Society Foundations, SciencesPo, UCL (eds.), University College London.

**Responsible for Module:**

Hottenrott, Hanna; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Volkswirtschaftslehre II (WI000023) (Vorlesung, 2 SWS)

Hottenrott H

Volkswirtschaftslehre II (WI000023): Übung (Übung, 2 SWS)

Hottenrott H, Römer K, Vollert G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### ED0152: Knowledge and Cognition (advanced topics) | Erkenntnis und Kognition (vertieft)

Version of module description: Gültig ab summerterm 2014

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>135  | <b>Contact Hours:</b><br>15          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Das Modul wird mit einer Modulprüfung in Form einer Seminararbeit (3000 Wörter) oder eines Vortrags (35 min) abgeschlossen.

Um die Lernziele zu erreichen, ist neben theoretischem Input und Eigenstudium auch aktive Mitarbeit im Rahmen der Lehrveranstaltung notwendig. Deshalb werden Mid-Term-Leistungen angeboten, die - als Anreiz für die Studierenden - zu einer Verbesserung der Bewertung der Modulprüfung führen können. Mögliche Mid-Term-Leistungen sind: Referat, Gespräch, Protokoll/Rekapitulation, Essay, Mitarbeit in der Präsenzzeit und in Online-Foren, Übungs-/Hausaufgaben. Art und Umfang der vorgesehenen Mid-Term-Leistungen werden in der Beschreibung der Lehrveranstaltung veröffentlicht.

Alle Einzelleistungen werden benotet. Die Gesamtnote der Mid-Term-Leistungen ergibt sich aus den nach Workload gewichteten Einzelleistungen. Ist diese besser als die Note der Modulprüfung, wird die Gesamtnote aus dem gewichteten Mittel der Modulprüfung und der Mid-Term-Leistungen errechnet. Die Gesamtnote der Mid-Term-Leistungen wird bei der Wiederholung einer nicht bestandenen Modulprüfung berücksichtigt.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Modul "Erkenntnis und Kognition" (ED0145)

#### Content:

Vertiefende Behandlung von Themen aus dem Modul "Erkenntnis und Kognition" und/oder Erörterung weiterführender Themen unter Berücksichtigung aktueller Entwicklungen und neuerer Forschungsergebnisse.

**Intended Learning Outcomes:**

Die Teilnehmer besitzen vertiefte Kenntnisse über exemplarische Problemfelder und Forschungsdebatten der Erkenntnistheorie, Kognitionspsychologie bzw. philosophy of mind. Sie sind in der Lage, Informationen und Quellen eigenständig aufzubereiten und zu präsentieren. Sie können komplexe Sachverhalte und Argumentationen systematisch analysieren sowie klar und strukturiert vermitteln. Insbesondere entwickeln sie die Fähigkeit, fachspezifisches Wissen in übergreifende Zusammenhänge zu integrieren und interdisziplinär zu vermitteln.

**Teaching and Learning Methods:**

Seminar, Referate, Diskussionen, Selbststudium insbes. eigenständige Erarbeitung eines Themas

**Media:**

Skripte/Reader, Thesenpapiere, Tafelbilder, Power-Point, Literatur zur Lektüre

**Reading List:****Responsible for Module:**

Jörg Wernecke (wernecke@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI000231: Asset Management | Asset Management

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The grading is based on an open-book e-test with a duration of 90 minutes. The e-test consists of calculations and multiple choice questions. By answering questions in multiple choice or text form, students have to show that they are able to understand the theory behind Asset Management (e.g. concept of utility and the calculation of basic utility measures, portfolio selection under various constraints, determinants of the capital asset pricing model and other factor models). Moreover they show their ability to explain the basic models e.g. of portfolio theory. By performing calculations and elaborating on theoretical considerations, students demonstrate their ability to evaluate and apply the methods presented in the module. They show that they are able to consider asset pricing models.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

MA9712 "Introductory Statistics" (Recommended)

MA9711 "Introductory Mathematic" (Recommended)

#### Content:

The target of the module is to familiarize students with the concept of Asset Management from a theoretical perspective. The module provides the theoretical foundation that is required to understand typical problems in Asset Management and illustrates how to solve these problems effectively by means of the appropriate tools (e.g. Excel Solver).

The following contents are addressed:

- Utility Theory and decisions under uncertainty

- Theory and application of basic models of portfolio theory with a particular focus on portfolio optimization under various constraints in the Markowitz mean-variance framework
- Theory and application of asset pricing models (e.g. Capital Asset Pricing Model, Arbitrage Pricing Theory)
- Theory and application of conditional asset pricing
- Portfolios Performance Measurement

**Intended Learning Outcomes:**

After successful completion of the module, students (1) understand the concept of utility theory (utility functions and link to risk attitudes) and can (2) calculate basic utility measures (absolute risk aversion, relative risk aversion, expected utility, certainty equivalent, risk premium); Students can also (3) explain and apply the basic models of portfolio theory, i.e. they can calculate the optimal portfolio allocation in the Markowitz mean-variance framework for an arbitrary set of asset returns under various constraints. Moreover, students (4) understand the fundamental concept of the Capital Asset Pricing Model and are able to (5) apply the model and its variants introduced in the module and also recognize the shortcomings of this model. Students (6) learn to use other asset pricing models and when to apply them. Finally, students (7) learn the theory, process and methods to measure the portfolios' performance.

**Teaching and Learning Methods:**

The module combines various learning methods:

- Basic knowledge, theoretical concepts and practical examples will be provided through the lecture.
- Controversial discussions and active participation in class are encouraged to deepen understanding of the concepts presented.
- In the exercises, students will apply their theoretical knowledge to concrete
- Demonstration of how to apply portfolio optimization on real-world data by using Excel
- Students will get insights into practice via several guest lecture

**Media:**

Presentation slides, white board

**Reading List:**

Elton, E. J./ Gruber, M. J. (2006): Modern Portfolio Theory and Investment Analysis, USA, Wiley, 7th Edition.

Copeland, T. E./ Weston, J. F./ Shastri, K. (2006): Financial Theory and Corporate Policy, USA, Addison Wesley, 4th Edition.

**Responsible for Module:**

Kaserer, Christoph; Prof. Dr. rer. pol. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Asset Management (WI000231) (Vorlesung, 2 SWS)

Kaserer C [L], Goncalves de Azevedo V

Asset Management - Übung (WI000231) (Übung, 2 SWS)

Kaserer C [L], Goncalves de Azevedo V

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### ED0218: Science and Technology Communication | Wissenschafts- und Technikkommunikation

Version of module description: Gültig ab summerterm 2014

|                                |                            |                                  |                                             |
|--------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>120 | <b>Self-study Hours:</b><br>83   | <b>Contact Hours:</b><br>37                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung umfasst aufgrund der unterschiedlichen Lernergebnisse der beiden zugeordneten Veranstaltungen zwei Teilleistungen: (1) ein Essay (1000-1500 Wörter) zum Workshop (20%) und (2) ein Referat (inkl. schriftl. Ausarbeitung (1000-1500 Wörter)) im Seminar (80%).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

keine

#### Content:

Zeitung, Internet oder Science Center: Es gibt viele Gesichter der Kommunikation zwischen Wissenschaft und Öffentlichkeit. Immer mehr Wissenschaftler stellen sich auch dem Dialog auf dem Marktplatz. Welche Möglichkeiten der Vermittlung gibt es? Welche Herausforderungen stellen sich in der Kommunikation zwischen Wissenschaft, Medien, Politik und Öffentlichkeit? Wie kann ich als Wissenschaftler meine eigene Arbeit verständlich beschreiben? Wie lassen sich komplexe Sachverhalte interessant aufbereiten? Wie wird die gesellschaftliche Relevanz wissenschaftlicher Themen dargestellt?

#### Intended Learning Outcomes:

Nach der Teilnahme an den Modulveranstaltungen sind die Studierenden in der Lage, Probleme und Möglichkeiten der Wissenschafts- und Technikkommunikation zu verstehen und Techniken für eine effektive Kommunikation anzuwenden.

**Teaching and Learning Methods:**

Das Modul besteht aus Vortrag und Präsentationen des Dozenten, Einzel- und Gruppenarbeit zu praktischen Beispielen, Referaten zu historischen, didaktischen und sozialwissenschaftlichen Perspektiven. Aktive Teilnahme an den Lehrveranstaltungen.

**Media:**

PowerPoint, Filmausschnitte, Übungsaufgaben, Skriptum

**Reading List:**

Winfried Göpfert (Herausgeber): Wissenschafts-Journalismus: Ein Handbuch für Ausbildung und Praxis. Econ-Verlag, 2006.

Alexander Gerber: Trendstudie zur Wissenschaftskommunikation, 2011, [http://www.stifterverband.de/publikationen\\_und\\_podcasts/positionen\\_dokumentationen/wissenschaftskommunikation\\_trendstudie/wissenschaftskommunikation\\_trendstudie\\_2011.pdf](http://www.stifterverband.de/publikationen_und_podcasts/positionen_dokumentationen/wissenschaftskommunikation_trendstudie/wissenschaftskommunikation_trendstudie_2011.pdf).

**Responsible for Module:**

Heckl Wolfgang ([heckl@tum.de](mailto:heckl@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

KI Kommunikation (Seminar, 2 SWS)

Heckl W [L], Weitze M

KI Kommunikation (Seminar, 2 SWS)

Heckl W [L], Weitze M

Wissenschaft kommunizieren (Verständliche Texte, kontroverse Dialoge und mehr) (Workshop, 1 SWS)

Weitze M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ6030: Compulsory Module | Wahlmodul

Version of module description: Gültig ab summerterm 2010

|                      |                     |                          |                       |
|----------------------|---------------------|--------------------------|-----------------------|
| <b>Module Level:</b> | <b>Language:</b>    | <b>Duration:</b>         | <b>Frequency:</b>     |
| <b>Credits:*</b>     | <b>Total Hours:</b> | <b>Self-study Hours:</b> | <b>Contact Hours:</b> |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

#### Intended Learning Outcomes:

#### Teaching and Learning Methods:

#### Media:

#### Reading List:

#### Responsible for Module:



**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### MCTS0036: Moderation (RESET) | Moderation (RESET)

*How to guarantee efficient group discussions and moderation*

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>68   | <b>Contact Hours:</b><br>22          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Students must submit a research paper (2000 to 3000 words) in which they demonstrate that they have gained a deeper understanding of successful moderation. They do so by analysing a case or reflecting their own and other's communication patterns and behaviour in group discussions and moderation situations. In the paper, students demonstrate that they have acquired a greater awareness for communication challenges and barriers with different stakeholders, as well as an empathic and also assertive communication attitude. Furthermore, they show that they are able to apply effective communication techniques for the creation and maintenance of respectful and results-oriented group discussions, and also to learn from experience and - if necessary or advisable - to modify critical group communication patterns.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

This Skills module is aimed at students currently enrolled in the M.A. program 'Responsibility in Science, Engineering and Technology'. Students from other English-language MA programs can apply to join the respective course provided there is sufficient space available.

#### Content:

It is a major challenge to communicate effectively with and to different stakeholders within the STS/RRI context (in project meetings, planning processes or field activities), especially when targeting the change of paradigms and behaviour. Involving different stakeholders such as fellow researchers and partners but also decision makers, entrepreneurs, and civil society in productive, interactive inter- and transdisciplinary meetings is a challenge and requires an informed and skilled intervention of the moderator. Relevant concepts for these interventions will be discussed and necessary skills will be trained.

### **Intended Learning Outcomes:**

This module is dedicated to the challenges of successful communication in multi-stakeholder environments. Participants will acquire the following skills needed to support and moderate meetings and discussions (involving 3-20 participants) effectively and guarantee consistent outcomes:

- awareness for communication challenges and barriers with different stakeholders
- empathic and at the same time assertive communication attitude in moderation situations
- application of effective moderation techniques (e.g. active listening, rephrasing, question techniques, establishing rapport)
- ability to use these techniques for the creation and maintenance of respectful and result-oriented group discussions
- ability to learn from experience and - if necessary or advisable - to modify critical group communication patterns

### **Teaching and Learning Methods:**

Lectures to transfer knowledge about moderation and mediation; interactive exercises and simulations (role plays) to train group communication and moderation techniques

### **Media:**

Whiteboard, flip chart, exercise sheets, exercises, role plays, films

### **Reading List:**

MOORE, Ch. (2014). The Negotiating Process - Practical Strategies for Resolving Conflict.- 4th revised Edition; Jossey-Bass Publishers. San Francisco, CA, USA.

FISHER, R. & Ury, W. (2012). Getting To Yes: Negotiating Agreement Without Giving In. 3rd revised Edition (1st Ed. 1983). Penguin Books. New York, NY, USA.

SCHULZ v. THUN, F. (2004) Seven Tools for Clear Communication: The Hamburg Approach in English Language; Arbeitsgruppe Beratung und Training, Fachbereich Psychologie; 69 p.

### **Responsible for Module:**

Bauer, Victoria; M.A.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Moderation - Facilitation Skills for Transdisciplinary Work Processes (Workshop, 1,5 SWS)

Schmitt S ( Hintermeier J )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### AR20091: Supplementary Introduction to Urbanism | Ergänzende Einführung Städtebau

Version of module description: Gültig ab summerterm 2018

|                                         |                            |                                  |                                      |
|-----------------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung wird in Form einer Übungsleistung und einer mündlichen Prüfung absolviert. Anhand kleiner urbanistischer Entwurfsaufgaben wird theoretisches städtebauliches Wissen auf seine Anwendung im konkreten Fall hin geprüft. Durch Transferleistung wird das Wissen in 2 Übungen zur analytischen Erfassung und Einordnung von Stadträumen, gesellschaftlichen Tendenzen und Referenzprojekten sowie Entwurfsstrategien angewandt. Bestandteile sind jeweils die Recherche vor Ort und die graphische Darstellung des thematisierten räumlichen Sachverhaltes. Ergänzend greift der Studierende ein Vorlesungsthema auf und erläutert dieses im abschließenden, mündlichen Prüfungsgespräch durch Anwendung auf einen Praxisfall. Dadurch wird die verbale Kommunikation städtebaulicher Sachverhalte in der Praxisanwendung abgeprüft.

Die Bewertungen der zwei zeichnerisch und schriftlichen Übungen und des Prüfungsgesprächs werden zusammengezogen und ergeben die Modulnote.

#### Repeat Examination:

Next semester / End of Semester

#### (Recommended) Prerequisites:

Das Modul AR20091 ist eine thematische Auskopplung aus dem Pflichtmodul AR 20016: Städtebau aus dem Bachelor-Studiengang Architektur und kann daher nicht von den (regulär für diesen Studiengang an der TUM eingeschriebenen) Studierenden dieses Studiengangs belegt werden.

AR20091 – Ergänzende Einführung Städtebau richtet sich an Studierende welche im Rahmen eines anderen Studiengangs oder eines Gastaufenthaltes an der TU München grundlegende Kenntnisse zu städtebaulichen Transformationsprozessen und in Konzepten und Werkzeugen des Städtebaus erwerben möchten. Für Studierende, welche erst ab der Masterstufe mit einem

Wechsel des Studiengangs das Thema Stadt vertiefen möchten, eignet sich AR 20091 als guter Einstieg in die Grundkonzepte, Werkzeuge und Elemente des Städtebaus.

**Content:**

Das Modul AR 20091: Ergänzende Einführung Städtebau vermittelt ein Grundverständnis für die Komplexität und Vielfalt städtischer Räume in der Erläuterung von Grundkonzepten, Werkzeugen und Elementen des Städtebaus. Topographie und Kontext, Körper und Raum, Ort und Geschichte, Nutzung und Gebrauch, Routinen und Rituale, Zeiträume und Bewegung, subjektives Gefühl und kollektive Erinnerung, Infrastruktur und wirtschaftliche Dynamik sind nur einige von vielen Faktoren, die der Analyse zugänglich sind. Der Maßstab umfasst den engeren Kontext im städtebaulichen Umfeld bis hin zu regionalen Strukturen, von der Stadt und ihrem Umland bis hin zur Region. Das städtebauliche Instrumentarium der Architektur wird systematisch auf diversen städtebaulichen Maßstabsebenen und mit unterschiedlichen thematischen Schwerpunktsetzungen angewendet.

**Intended Learning Outcomes:**

Nach der Teilnahme an den Modulveranstaltungen sind die Studierenden in der Lage,

- konkrete Stadträume in ihrer Komplexität und Vielfalt analytisch zu erfassen.
- zeitgenössische urbane Phänomene zu beobachten und zu entschlüsseln, zu deuten und in ihren jeweiligen Kontext einzuordnen.
- Referenzen räumlich orientierter Strategien für die Entwurfs- und Planungspraxis als Methoden und Werkzeuge im Entwurf einzusetzen
- wichtige zeitgenössische Grundkonzepte des Städtebaus, wie städtischer Mischung, Ordnung, Dichte, Öffentlichkeit, etc. zu überblicken und damit in entwerferischen Ansätzen zu argumentieren, und damit
- veränderte gesellschaftliche Tendenzen kreativ in urbane Projekte zu integrieren.

**Teaching and Learning Methods:**

Vorlesungen werden durch Übungen begleitet. Die Teilnahme an den Vorlesungen vermittelt das notwendige Wissen, das in den Übungen exemplarisch zur Anwendung gebracht wird. Die Recherche und Analyse des Kontextes als eine elementare Voraussetzung architektonischen Planens und Entwerfens wird trainiert. Dabei kommen zusätzlich unterschiedliche Medien der Präsentation zur Anwendung. Damit wird der Zusammenhang von inhaltlicher Aussage und Medien der Darstellung weiter trainiert.

Die als Prüfungsleistung zu erbringenden Übungsaufgaben und thematische Erarbeitung zum Prüfungsgespräch werden von den Studierenden in Eigenstudium sowie unter unterstützender Anleitung bearbeitet

**Media:**

Vorlesung, ggfs. Stadtwanderung, Exkursion, (weiterführende) Literaturrecherche und Internetrecherche.

**Reading List:**

Weiterführende Literatur wird themenspezifisch in den Vorlesungsveranstaltungen bekanntgegeben

**Responsible for Module:**

Mark Michaeli, Prof. Dipl.Arch. ETH

**Courses (Type of course, Weekly hours per semester), Instructor:**

Ergänzende Einführung Städtebau (Vorlesung, 2 SWS)

Michaeli M, Lemberger E, Numberger J

Städtebau: Städtebau (Vorlesung, 2 SWS)

Michaeli M, Lemberger E, Numberger J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### AR30002: Spatial Economy | Raumökonomie [RÖKMA]

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Examination consists of a 2-hour written exam as part of which the students have to demonstrate that they remember and understand theories, mechanisms and impacts of the economic development of space and property and that they are able to transfer these to a given problem. By transferring the theories the students show their ability to understand popular forms of visualization and description of economic drivers of spatial change in a specific case and to evaluate resulting challenges for the urban development.

Important notice in consideration of the restrictions on personal contacts due to the CoViD19 pandemic: If the general conditions (hygiene, distance rules, etc.) for an exam with personal attendance can not, or only under disproportionate effort, be ensured, the form of examination can be changed to either a written scientific report or a digital remote oral exam, in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at the latest 14 days before the exam date by the examiner after consultation with the responsible examination board.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The students should be aware of the main driving forces of spatial development on different scales and be able to analyse them. Basic skills in design and planning in the built environment are advantageous. Students should be able to comprehend space in different ways (morphological, territorial and functional). Furthermore, basic scientific skills are required. The course "Spatial Dynamics" and "Introduction to Scientific Methods" of the TUM Architecture Bachelor programme provide a good basis for successful completion of this module.

**Content:**

The module "Urban Economics" takes two different scales of spatial economy into account: The individual building or ensemble, and the large-scale spatial development in the city and region. The lecture "Urban Economics I" deals mainly with novel functional spaces and current issues of economic geography, such as Mega-City Regions and knowledge economy, and examines economic relationships and development drivers. The exercises are mainly about spatial analysis on different scales. Methodological skills for visualization, hypothesis formation and presentation of results are trained.

The lecture "Urban Economics II" deals with the individual property under economic aspects. Contents of the course are basic theories and contexts of real estate management and development.

**Intended Learning Outcomes:**

After attending the module the students are able to

- understand the main economic connections and driving forces of functional regions,
- understand how these forces control the morphology and development of space,
- assess the intended impact of territorial strategies,
- understand important mechanisms of the real estate market,
- reproduce and apply basic theories of real estate management and development,
- suggest territorial strategies,
- formulate correct hypotheses and to implement them,
- apply basic rhetorical and presentation skills.

**Teaching and Learning Methods:**

In the course external presenters and the staff at the chair provide presentations, tutored lectures and monitored discussions. Students are encouraged to study the suggested readings and discuss the topic.

**Media:**

In the two events essential content is presented by experts from practice and staff members in the form of lectures and inputs. Lecture slides and further literature is provided on the TUM online learning platform "Moodle".

**Reading List:**

Bentlage, Michael, Stefan Lüthi and Alain Thierstein (2013): Knowledge creation in German agglomerations and accessibility An approach involving non-physical connectivity. In: Cities, 30 (1), 47-58.

Brauer, Kerry-U. (2013): Grundlagen der Immobilienwirtschaft. Wiesbaden: Springer.

Conventz, Sven and Alain Thierstein (eds) (2014): Airports, Cities and Regions. Abingdon: Routledge.

Maennig, Wolfgang and Matthias Ottmann (2011): Perspektiven des deutschen Immobilienmarktes und wirtschaftspolitische Herausforderungen. In: Perspektiven der Wirtschaftspolitik, 12 (2), 192-214.



Müller-Stewens, Günter and Christoph Lechner (2005): Reflexion: Theoretische Ansätze des Strategischen. In: Günter Müller-Stewens and Christoph Lechner (eds) (2005): Strategisches Management, 144-158.

Ottmann, Matthias (2005): Public-Private Partnerships im Lichte der ökonomischen Vertragstheorie. In: Bach, Hansjörg, Matthias Ottmann, Erwin Sailer and Frank Peter Unterreiner (eds) (2005): Immobilienmarkt und Immobilienmanagement, 179-215.

Ottmann, Matthias (2009): Immobilienmärkte als Forschungsthema der Wirtschaftsgeographie. In: Martin Hess and Reinhard Paesler (eds): Wirtschaft & Raum: Wege und Erträge der Münchner wirtschaftsgeographischen Forschung, 55-67.

**Responsible for Module:**

Thierstein, Alain; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Multidisziplinäre Perspektive Raumentwicklung: Raumökonomie II (Immobilienwirtschaft und Stadtentwicklung) (Vorlesung, 2 SWS)

Ottmann M

Multidisziplinäre Perspektive Raumentwicklung: Raumökonomie I (Raumstruktur und Regionalentwicklung) (Vorlesung, 2 SWS)

Thierstein A, Wenner F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### AR30294: Climate Responsive Building I | Klimagerechtes Bauen I

Version of module description: Gültig ab winterterm 2018/19

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Duration time 60 minutes. Written exam.

At the end of the module the proof of performance will be a written examination. In the exam the students proof that they are able to evaluate the complex correlation of climate responsive and energy optimized building. On the basis of practical examples it is examined that the students are able to create appropriate measures and concepts. Content is over the whole semester. Answers can be given in own words or given single-choice-questions. Furthermore basic calculations should be solved.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Grundkenntnisse der Gebäudetechnik, Kenntnisse über die Bilanzierung von Gebäuden in energetischer und ökologischer Hinsicht.

#### Content:

- Climate and climatic parameters
- Fundamentals of energy and renewable energy
- Thermal comfort
- Climate responsive building: architecture strategies (passive) to optimize the building climate and energetic supply of buildings through an integrated planning approach
- Integration of building's envelope and building technology (adjusting screw of the facade and adjustment of facade and room conditioning)
- Winter and summer insulation
- Energy balance of the building in heating and cooling mode

- Room conditioning: heating, cooling
- Technical building installation
- Energy conversion and energy supply, central and decentralised energy supply concept, energy storage
- Simulation tools
- Legal and energy economical framework

### **Intended Learning Outcomes:**

At the end of the module climate responsive building students are able to

- design holistic, climate responsive and energy optimized building concepts
- create sustainable concepts of room conditioning and energy supply for buildings and quarters
- evaluate passive (architectural) measures for minimizing the energy demand of buildings while optimizing the comfort
- adapt individual technical systems of room conditioning to the building concept or coordinate the individual systems among themselves
- analyse practical examples with regard to climate responsive and energy optimized buildings
- understand the current political and scientific state of debate regarding to buildings and urban structures in the context of the energy revolution

### **Teaching and Learning Methods:**

The practical relevance is established by current projects and students' discussion. In the weekly lectures the content of the module is mediated in form of lecture and presentation and tested in a written exam.

### **Media:**

PowerPoint presentation, script, blackboard

### **Reading List:**

### **Responsible for Module:**

Vohlidka, Philipp; Dipl.-Ing. (Univ.)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Klimagerechtes Bauen I (Vorlesung, 2 SWS)

Auer T, Vohlidka P, Wagner T, Zettelmeier C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### AR30309: Conservation of historical buildings today I | Denkmalpflege heute I

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In Form einer mündlichen Prüfung (20 min.) werden anhand von grundsätzlichen Fragen und praxisbezogenen Fallbeispielen das Verständnis für Aufbau, Arbeitsweise und Vernetzung der Denkmalbehörden überprüft. Insbesondere auf die differenzierte Abwägung der Handlungsoptionen unter Beachtung der gesetzlichen Grundlagen wird in der Prüfung großer Wert gelegt wird.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

Das Modul vermittelt in Vorlesungen und Ortsterminen Einblicke in die Problemstellungen heutiger Denkmalpflege. Vorgestellt werden die wesentlichen Aufgabenbereiche des Landesamts für Denkmalpflege und die rechtlichen Grundlagen. Denkmalpflege heute I dient der Vermittlung des fachspezifischen Grundlagenwissens zum Umgang mit denkmalgeschütztem Gebäudebestand und den speziellen Anforderungen an die institutionellen Strukturen, die sich aus der Vielzahl und Vielfalt der geschützten Bauten ergibt.

#### Intended Learning Outcomes:

Nach der Teilnahme am Modul Denkmalpflege heute I sind die Studierenden in der Lage, Aufbau und Arbeitsweise der oberen Denkmalbehörde zu verstehen und die komplexe Vernetzung mit anderen Behörden und Ämtern zu erklären. Im Focus steht:

- das Verständnis für die denkmalpflegerrelevante Gesetzeslage und denkmalpflegerische Konventionen
- das Denkmalgesetz als Grundlage für die Praxis der institutionellen Denkmalpflege
- die Abwägung von Methoden und Strategien für bauliche Maßnahmen im denkmalgeschützten Bestand

**Teaching and Learning Methods:**

Vorlesungen vermitteln ein Verständnis für die heutige denkmalpflegerische Konvention anhand der Betrachtung der Geschichte und Entwicklung der Denkmalpflege in Deutschland und der sich daraus entwickelten Gesetzeslage.

Vorgestellte Beispielprojekte zeigen das Spektrum der möglichen Strategien und die Umsetzung der baulichen Maßnahmen. Ergänzende Ortstermine in den Außenstellen des Landesamtes für Denkmalpflege und des Landesamtes selbst geben Einblick in die praktische Arbeit der Ämter und veranschaulichen die komplexe Vernetzung der Ämter.

**Media:**

Vorlesungen mit Präsentation  
Exkursionen

**Reading List:**

**Responsible for Module:**

Hild, Andreas; Prof. Dipl.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Denkmalpflege Heute I (Vorlesung, 2 SWS)

Pfeil M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### AR30320: Technoscience and the City: Advances in Urban Theory | Technoscience and the City: Advances in Urban Theory

Version of module description: Gültig ab winterterm 2015/16

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Students will have to submit a final essay or report, which will measure not only the student's ability to critically understand and evaluate the role of technoscience in contemporary urbanization processes, as well as the material politics, sociotechnical imaginaries, invisible work, and knowledge controversies shaping contemporary urban assemblages, but also the capability of proposing original analyses of historical or contemporary developments.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

Think of urban waste management, transport flows, noise abatement or tourist practices. Cities are made of multiple sociotechnical assemblages bringing together humans and non-humans, such as technologies, microbes, fuel or maps, in all sorts of ways for all sorts of purposes. For a long time, however, urban studies have mostly focused on the political economy of cities, on the logics of capital accumulation and class struggles shaping urbanization processes, overlooking the often contested role played by technoscience in shaping sociotechnical assemblages.

This module introduces students to new theoretical approaches, conceptual repertoires and understandings of the urban, urbanity and urbanization that, inspired in science and technology studies, address the sociotechnical complexity of cities. Key issues addressed in this module include:

1. Histories of urban materials and technologies

2. Cities as technological artifacts and sociotechnical assemblages.
  - a. Performative, relational and fluid understandings of space
  - b. Buildings as quasi-technologies and the dynamics of sociotechnical systems
  - c. Cyborg and hybrid forms of urban life: infrastructural and inter-species assemblages
3. Urban cosmopolitics and the right to infrastructure

#### **Intended Learning Outcomes:**

1. Understanding the role played by materials and technologies in the history of urbanization and modes of urban coexistence
2. Analysing, through case studies, the sociotechnical assemblages, knowledge politics and hybrid urbanities emerging in contemporary processes of urban transformation
3. Critically evaluating and experimentally exploring the more-than-human politics of grassroots and citizen projects.

#### **Teaching and Learning Methods:**

Teaching methods will include lectures, student presentations, in-class discussion of case studies and key texts, project work in groups, as well as regular discussions with the lecturer.

Lectures have the aim of introducing students into larger historical developments, conceptual genealogies and disciplinary contexts, as well as providing background information about the key authors to be discussed. The student's oral presentation is a means to foster not only the student's ability (a) to read analytically and engage critically with the suggested readings, but also (b) to conduct a discussion, through case studies, analysing the strengths, consequences, and problems of the arguments and case studies there present. In-class discussion of texts further fosters student's capabilities to recognize and react to different readings and interpretations of a text, as well as to dialogically work towards a common understanding of key arguments. Project work in groups aims at fostering the student's inventive skills to develop a theoretical or practical proposal. Regular discussions with the tutor ensure the student's ability to develop different insights for the completion of the final essay.

#### **Media:**

#### **Reading List:**

- Amin, A. & Thrift, N. (2002) *Cities. Reimagining the Urban*. Cambridge: Polity Press.
- Blok, A. & Farías, I. (Eds.) (2016) *Urban Cosmopolitics. Agencements, Assemblies, Atmospheres*. London: Routledge
- Corsín, A. (2014) The right to infrastructure: a prototype for open source urbanism. *Environment and Planning D: Society and Space* 32(2): 342-362
- Farías, I., & Bender, T. (Eds.). (2009). *Urban Assemblages: How Actor-Network Theory Changes Urban Studies*. London: Routledge.
- Graham, S. & Marvin, S. (2001) *Splintering Urbanism: Networked Infrastructures, Technological Mobilities, and the Urban Condition*. London: Routledge.

Guggenheim, M. & Söderström, O. (Eds.) (2009) Re-shaping Cities. How Global Mobility Transforms Architecture and Urban Form. London: Routledge  
Heynen, N. Kaika, M. & Swyngedouw, E. (Eds.) (2006) In the nature of cities: urban political ecology and the politics of urban metabolism. London: Routledge  
Latour, B. & Hermant, E. (1998) Paris Ville Invisible. Paris: La Decouverte

**Responsible for Module:**

Farias Hurtado, Ignacio; Prof. Dr. phil.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Ignacio Farías

Tomás Sanchez Criado tomas.criado@tum.de

Laurie Waller laurie.waller@tum.de

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### AR30331: Conservation of historical buildings today II | Denkmalpflege heute II

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In Form einer mündlichen Prüfung (20 min.) werden anhand von grundsätzlichen Fragen und praxisbezogenen Fallbeispielen das Verständnis für Aufbau, Arbeitsweise und Vernetzung der Denkmalbehörden überprüft. Insbesondere auf die differenzierte Abwägung der Strategien und Methoden, sowie die Umsetzung der baulichen Maßnahme unter Beachtung der gesetzlichen Grundlagen wird in der Prüfung großer Wert gelegt.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Teilnahme am Modul Denkmalpflege heute I.

#### Content:

Aufbauend auf das Modul Denkmalpflege heute I, vermittelt das Modul in Vorlesungen und Ortsterminen Einblicke in das Berufsbild der institutionellen Denkmalpflege. Insbesondere die Anwendung des Denkmalschutzgesetzes in Bezug auf Bauaufgaben im denkmalgeschützten Bestand wird als wesentlicher Aufgabenbereich des Landesamts für Denkmalpflege vermittelt. Zum einen werden die rechtlichen Grundlagen als theoretische Basis vorgestellt und in ihrer Bedeutung analysiert. Zum anderen erhalten die Studierenden Einblick in die Umsetzung der normativen Texte in der denkmalpflegerischen Praxis vor Ort. Insbesondere wird das Bewusstsein für die spezifischen Anforderungen für jedes Einzelobjekt geschärft und Wege der individuell abzustimmenden Handlungsweisen aufgezeigt.

**Intended Learning Outcomes:**

Nach der Teilnahme am Modul Denkmalpflege heute II sind die Studierenden in der Lage, Aufbau und Arbeitsweise der oberen Denkmalbehörde zu verstehen und die komplexe Vernetzung mit anderen Behörden und Ämtern zu erklären. Im Focus steht:

- das Bewertung der denkmalpflegerelevanten Gesetzeslage und relevanter technischer Normen
- die Kenntnis über Verfahrenswege und praktischen Vollzug des Denkmalgesetzes
- die Abwägung von Methoden und Strategien für bauliche Maßnahmen im denkmalgeschützten Bestand
- die Fähigkeit eigenständige Lösungen zum adäquaten Umgang mit denkmalgeschütztem Gebäudebestand zu kreieren

**Teaching and Learning Methods:**

Vorlesungen vermitteln ein Verständnis für die heutige denkmalpflegerische Konvention anhand der Betrachtung von vorgestellten Beispielprojekten an denen verschiedene Verfahren zur Umsetzung des Denkmalgesetzes aufgezeigt werden, sowie unterschiedliche bauliche Umsetzungen verglichen werden. Ergänzende Ortstermine in den Außenstellen des Landesamtes für Denkmalpflege und des Landesamtes selbst geben Einblick in die praktische Arbeit der Ämter. Ortstermine in baulichen Referenzprojekten veranschaulichen die konkrete Durchführung denkmalpflegerischer Bauaufgaben.

**Media:**

Vorlesungen mit Präsentation  
Exkursionen

**Reading List:****Responsible for Module:**

Hild, Andreas Pfeil, Mathias

**Courses (Type of course, Weekly hours per semester), Instructor:**

Denkmalpflege Heute I (Vorlesung, 2 SWS)

Pfeil M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### AR30386: European Mega City Regions | European Mega City Regions [EMCR]

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a 60-minute written exam. In the exam, students have to recall conceptual foundations, theories and findings from spatial development. The exam consists of open questions, which improve writing and communication skills.

Important notice in consideration of the restrictions on personal contacts due to the CoViD19 pandemic: If the general conditions (hygiene, distance rules, etc.) for an exam with personal attendance can not, or only under disproportionate effort, be ensured, the form of examination can be changed to exercises, particularly e-Tests, in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at the latest 14 days before the exam date by the examiner after consultation with the responsible examination board.

The examination consists of one e-test. The examination date will be announced in time in the course description.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The students should comprehend spatial drivers and they should be able to analyse spatial development on different scales. Basic skills in design and planning in the built environment are required. Students are able to consider spaces in different ways (morphological, territorial and functional). Furthermore, basic scientific skills are required. The module "Urban Economics" and "Introduction to Scientific Methods" of the Bachelor programme in Architecture provide the basis for successful completion of this module. Sufficient proficiency in English is necessary.

**Content:**

The module European Mega - City Regions focusses on functional spaces, such as polycentric metropolitan areas and the development drivers. This course assesses spatial development, spatial strategies and their consequences on the built environment. Technical contents are the understanding of space (space as a distance function and process); spatial analysis on different scales; functional drivers of spatial development; to understand different logics space: functional, territorial, morphologically and the application of these approaches in practice; functional spaces; strategies of spatial development and the intended as well non-intended consequences of these strategies. Methodological issues are: visualization, hypothesis formulation and presentation of results orally and in a written exam.

**Intended Learning Outcomes:**

After attending the module the students are able to

- understand what functional regions are,
- understand which factors drive the functional regions,
- understand how these drivers control the morphology and development of these regions,
- assess the intended impact of territorial strategies,
- suggest territorial strategies,
- formulate correct hypotheses and implement them, and
- apply basic rhetorical and presentation skills.

**Teaching and Learning Methods:**

In the course external presenters of science and practical work and the staff of the chair provide presentations, tutored lectures and monitored discussions. Students are taught analytic reading and to discuss content. Students deepen their skills in teamwork and present their results at the end of the course. The lecturers guide and monitor this teamwork.

**Media:**

Presentations; These will be provided to the participants on the TUM learning platform

**Reading List:**

Hall, Peter und Kathy Pain (2006): The Polycentric Metropolis. Learning from Mega-City Regions in Europe. London: Earthscan.

Lambregts, Bart (2009): The Polycentric Metropolis Unpacked. Concepts, Trends and Policy in the Randstad Holland. Bangkok: Pimsuay Co., Ltd.

Lüthi, Stefan, Alain Thierstein und Viktor Goebel (2010): Intra-firm and extra-firm linkages in the knowledge economy: the case of the emerging mega-city region of Munich. In: Global Networks, 10(1), 114-137.

Pain, Kathy (2008): Examining "Core-Periphery" Relationships in a Global City-Region: The Case of London and South East England. In: Regional Studies 42(8), 1161-1172.

Taylor, Peter J., David M. Evans und Kathy Pain (2008): Application of the interlocking Network Model to Mega-City-Regions: Measuring Polycentricity Within and Beyond City-Regions. In: Regional Studies 42(8), 1079-1093.

**Responsible for Module:**

Thierstein, Alain; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

European Mega-City Regions (Seminar, 2 SWS)

Thierstein A, Heidinger M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU36008: Methods of Measurement | Messtechnik Seminar

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                  |
|--------------------------------|----------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Proof of performance is provided by submitting a term paper in the form of a report at the end of the semester, from which the grade for the module results.

The aim of the elaboration is to prove that the topics worked out in the course of the seminar were understood from the building physics and metrological context and can be reproduced in writing.

During the course, problems relating to a building physics phenomenon must be analysed and solutions to specific measurement tasks must be found, implemented and documented.

The creation of the seminar paper requires a scientifically correct reproduction of learned processes and methods.

For the production of the seminar work all aids are permitted. A scientifically correct way of working (especially citation) is important.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Basic understanding of building physics contexts
- Understanding planning documents
- Constructive understanding of structures and details

Building Physics Basic Module

Building Physics - Supplementary Module

Measurement techniques

#### Content:

- Current, mostly interdisciplinary topics from different areas of building physics such as humidity, sound, heat, light, sustainability and their measurement requirements

- Measurement technology and practical construction applications
- Introduction to necessary special software and hardware

**Intended Learning Outcomes:**

In small, often interdisciplinary teams, a topic of building physics is analyzed using measurement techniques. After taking part in this course, the students are able to carry out a professional measurement and subsequently to develop an understanding of a corresponding building physics context. They will be able to generate a related documentation.

**Teaching and Learning Methods:**

The course includes lectures and workshops with experiments. In addition, students are provided with further information on the individual topics in an online learning room.

This makes it possible to interact intensively with the students, to answer questions promptly and personally and to carry out the experiments and measurements independently. Questions can be discussed in the online learning room and additional information on individual topics can be provided.

**Media:**

Powerpoint-Präsentationen und themenabhängige Fachliteratur,  
ggf. spezielle Software aus dem Bereich Messtechnik und Messdatenerfassung

**Reading List:**

Fachliteratur wird speziell an die jeweiligen Themen angepasst zur Verfügung gestellt.

**Responsible for Module:**

Klaus Peter Sedlbauer

**Courses (Type of course, Weekly hours per semester), Instructor:**

Messtechnik Seminar (Seminar, 2 SWS)

Talke M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU36011: Seminar Climate-Culture-Building in Building Physics | Seminar klima- und kulturgerechtes Bauen in der Bauphysik [Seminar Climate-Culture-Building in building physics]**

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                  |
|--------------------------------|----------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The examination is carried out by submitting a 15-25 pages project documentation, which has to be worked out in groups. Components of the elaboration are the analysis of the climate, the building culture and the resources of the respective selected region, as well as the development of a building concept of an ideal residential building based on it. In addition, a concise summary of the results should be provided. The students should prove that they are able to create a building physics building concept with focus on comfort of the users. The influences from the building culture and the climate of selected regions must be considered. Furthermore, the results will be presented in a presentation. Herby, the students prove that they can present their results in an understandable way. Each group member must identify his/hers part of the solution developed for the overall task.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Building Physics Basic Module

Building Physics - Supplementary Module

#### **Content:**

At the beginning basic building physics requirements of a residential building with regard to room climate and comfort will be repeated:

- Heat/Cold
- damp
- acoustics
- light



- fresh air

Subsequently, the regionally dependent influences on the basic building physics requirements are communicated. The focus is on:

- building culture
- climate
- Resource-saving construction

Furthermore, the topic of building physics concepts for residential buildings in the sense of sustainability is dealt with.

### **Intended Learning Outcomes:**

After participation the students are able

- to remind themselves of the basic building physics requirements of a residential building,
- to understand the relationship between building physics requirements and the regionally dependent climate as well as home decor,
- to apply this knowledge to analyse selected regions in terms of their respective parameters,
- to develop a building physics building concept taking into account climatic and cultural influences of different regions in terms of sustainability.

### **Teaching and Learning Methods:**

In the first project phase, the basics of climate- and culturally appropriate construction are taught in classical presentations. This is followed by an analysis of the parameters of the respective region, which is accompanied by consultation appointments. In the second project phase, students are prepared for the building physics concept in classical lectures. The development of the concepts is accompanied by cyclical consultations and discussions. Finally, the results will be presented. One or more short excursions are planned.

### **Media:**

blackboard, powerpoint presentations, eTeaching

### **Reading List:**

Grundlagenliteratur: G.Hausladen (2012): Klimagerecht Bauen - Ein Handbuch, weitere Literatur wird speziell an die jeweilige zu bearbeitende Region angepasst zur Verfügung gestellt.

### **Responsible for Module:**

Klaus Peter Sedlbauer

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Seminar

Klaus Peter Sedlbauer

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU37016: Optimization of building materials for practical applications | Anwendungsgerechte Optimierung mineralischer Baustoffe

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Der Leistungsnachweis erfolgt in Form einer 60-minütigen, schriftlichen Klausur. Mithilfe dieser Klausur soll nachgewiesen werden, dass der Studierende ein grundlegendes Verständnis mineralischer Baustoffe und anwendungsgerechter Optimierung komprimiert und unter zeitlichem Druck wiedergeben kann. Die Prüfung besteht aus allgemeinen Fragen, in deren Antworten die Studierenden erörtern und diskutieren, stichpunktartig beschreiben und aus vorgegebenen Mehrfachantworten die richtige Antwort ankreuzen müssen. Teils müssen auch kleine Rechenaufgaben gelöst werden.

Die Form der schriftlichen Prüfung ermöglicht somit eine realistische Einschätzung bezüglich der im Rahmen des Moduls erlangten unterschiedlichen Erkenntnisstufen.

Außer einem Taschenrechner sind keine weiteren Hilfsmittel erlaubt.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Abgeschlossenes Bachelorstudium des Bauwesens (Architektur, Bauingenieurwesen o.ä), der Ingenieur- oder Naturwissenschaften; Grundlagenausbildung in den Gebieten Mathematik, Physik, Chemie, Werkstoffkunde - idealerweise der mineralischen Werkstoffe.

#### Content:

Darstellung aktueller Baustoffentwicklungen in den Bereichen Konstruktions-, Fassaden- und Ausbauwerkstoffe. Behandlung der Entwicklungsziele für Werkstoffe für modernes Bauen und der erforderlichen Entwicklungsstrategien gegliedert in folgende Teilbereiche:

- Zementhydratation, -chemie und -eigenschaften
- Latent-hydraulische und puzzolanische Betonzusatzstoffe
- Schnell- und Quellzemente
- Sonderzemente: low energy binder
- Behandlungsmethoden zur Entwicklung neuer Baustoffe
- Mehrkomponentige Bindemittel
- Betone zur Vorbeugung von Alkali-Kieselsäure Reaktion
- Betone mit hohem Sulfatwiderstand
- Betone mit nachwachsenden Rohstoffen
- Multifunktionale Baustoffe, Multifunktionalität, Nanotechnologie, Bionik und Werkstoffkombinationen mit nachwachsenden Rohstoffen

### **Intended Learning Outcomes:**

Nach der Teilnahme am Modul sind die Studierenden in der Lage, die für technische Anwendungen relevanten Eigenschaften von neu entwickelten mineralischen Baustoffen zu erfassen und die Werkstoffe anwendungsgerecht zu optimieren.

Die Studierenden sind in der Lage zu beurteilen, in wie weit Baustoffeigenschaften durch die Rohstoffauswahl und die eingesetzte Prozesstechnik verändert werden können und welche erforderlichen Anpassungen im Herstellprozess für eine Modifizierung der Baustoffeigenschaften notwendig sind. Darüber hinaus sind die Studierenden fähig, Schadensreaktionen zu analysieren und vorbeugende Maßnahmen im Hinblick auf die verwendeten Baustoffe zu erläutern.

### **Teaching and Learning Methods:**

In der Veranstaltung werden die wesentlichen Lehrinhalte grundsätzlich in Form einer klassischen Vorlesung mit ständiger Unterstützung durch eine PowerPoint-Präsentation vermittelt. Auf das eigenverantwortliche Studium der Fachbegriffe und der grundlegenden Zusammenhänge an Hand der Vorlesungsunterlagen, der Mitschriften und der empfohlenen Literatur wird großer Wert gelegt. Um den Studierenden Aktualität und Relevanz des Themas näher zu bringen werden aktuelle Fragestellungen aus der Forschung zuerst in Kleingruppen behandelt und dann gemeinsam mit dem Dozenten am Flipchart eingeordnet, erörtert und in den Gesamtkontext eingebettet. Besondere Detailspekte oder für das Gesamtverständnis bedeutende Gesichtspunkte werden durch Tafelanschrieb schrittweise hergeleitet und anschaulich erläutert. Dieses Vorgehen ermöglicht den Studenten eine übersichtliche und klar lesbare Darstellung der Inhalte und fördert das konzentrierte Zuhören und somit auch das Verständnis der Studenten, da diese nicht durch ein permanentes Mitschreiben des Tafelanschriebs abgelenkt werden. Teilweise werden Anschauungsmaterialien zur besseren Darstellung und zum besseren Verständnis der Sachverhalte verwendet. Filme zu Versuchen und Verfahren werden integriert. Berechnungsbeispiele werden auf Overheadfolien oder an der Tafel unter Einbeziehung der Studierenden durchgeführt.

### **Media:**

- Powerpoint
- Tafel- oder Tablet-PC-Anschriebe

- Videos

**Reading List:**

Zu Beginn der Vorlesung wird eine Liste aktueller Literaturstellen vom Dozenten verteilt

**Responsible for Module:**

Machner, Alisa; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Anwendungsgerechte Optimierung mineralischer Baustoffe (Vorlesung, 2 SWS)

Heisig A [L], Heisig A, Woydich E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU37019T2: Seminar - Ecology in Building and Construction | Seminar Ökologisches Bauen

Version of module description: Gültig ab summerterm 2022

|                                |                            |                                  |                                             |
|--------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The students work in teams of two self-dependently on relevant problems and compile a written report. The report examines the extent to which the students are able to present the obtained information and technical contexts scientifically in writing. The paper should comprise approx. 20 pages and will be graded. The papers will be made available to all course participants afterwards. In addition, a peer review of a draft version of the paper will be carried out by all students during the semester. Through the peer review process, students receive feedback on preliminary versions of their reports during the semester. The peer review also gives students an insight into an additional topic and into alternative approaches to implementing and structuring the paper and increases their ability to give a critical but constructive feedback. By carrying out a peer review instead of a correction by the lecturer, a change of perspective is initiated, which enhances the motivation and learning outcome of the students. The peer review is assessed as a compulsory but ungraded course achievement.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Completed bachelor's degree in civil or environmental engineering, architecture, or similar engineering fields or natural sciences.

#### Content:

- Introduction to the topics of sustainability, ecology and climate change with reference to the building industry
- Current challenges of ecological constructions

- The life cycle of building materials and structures
- Content-related and methodological basics of life cycle assessments (LCA)
- Forms of recycling for building materials, components and constructions
- Assessment of the environmental and health compatibility of building materials, components and constructions
- Consideration of the processes and procedures of life cycle assessment methods in general (life cycle inventory, impact assessment, etc.)
- Application of life cycle assessment tools to assess the sustainability of building materials, components and constructions, but also (de-)construction processes referring to national and international assessment methods

### **Intended Learning Outcomes:**

Upon completion of the module, students are able to:

- classify essential environmental impacts and their evaluation criteria of selected building materials, components and constructions over their entire life cycle
- assess national and international standards and methods for life cycle assessment in the building industry and apply life cycle assessment tools where appropriate
- critically assess a specific topic on the basis of current literature and compile it scientifically in written form for an expert group of readers of fellow students and the lecturers
- critically analyse an unknown topic through the peer review process and provide constructive, fair feedback and use this for improvement of their own report

### **Teaching and Learning Methods:**

Following an introductory session and the choice of topics, meetings with the lecturers take place to discuss literature research, problem analysis, structuring the results and evaluation criteria. During these discussions, the lecturers provide support in the preparation and elaboration of the written work. The focus is on the introduction to scientific work in general, as well as on the basics for the design and structure of a written report. This takes place in individual discussions in order to be able to specifically address the individual questions of each student.

In addition to the meetings with the lecturers, a peer review is carried out during the semester. For the peer review, the groups are each provided with a draft report of another group for assessment. The assessments are then communicated to the respective authors in writing. Through the peer review process, students should have the opportunity to critically analyse other people's work and to give constructive, fair feedback and use this for the improvement of their own report.

The seminar-based outline of the module enables students to independently design, reflect and expand their own learning process. In addition, students improve their abilities to work cooperatively and responsibly in groups as well as to present complex subject-related content clearly and in a target group-oriented manner in a written format.

### **Media:**

- PowerPoint presentations (content: pictures, illustrations of mechanisms, diagrams)

- Individual meetings with the lecturer (in presence or online)

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**Reading List:**

The recommended literature depends on the chosen topic and will be discussed individually with each group during the meetings.

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**Responsible for Module:**

Machner, Alisa; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Seminar Ökologisches Bauen (Seminar, 2 SWS)

Machner A, Heisig A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38010: Advanced Water Treatment Engineering and Reuse | Weitergehende Wasserbehandlung und Wasser Recycling

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a 60-minute written open book test consisting of theoretical questions and calculation tasks.

The aim of the theoretical questions is to demonstrate that students understand approaches to typical tasks in advanced water treatment and water reuse. On the basis of practical tasks, the students show that they are able to design sites for water reuse as well as estimate the related hazard potential and develop process optimization using technical guidelines and legal requirements.

Students have to analyze water engineering tasks in a limited time, find and implement suitable solutions. The answers sometimes require own formulations, the focus being however on short calculation tasks. Beside for a non-programmable pocket calculator, aids like handouts and personal notes are allowed during the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering (BGU38014)

#### Content:

- 1.Introduction to water reuse and seawater desalination
- 2.Regulatory and technical requirements for reuse
- 3.Treatment trains to facilitate non-potable reuse
- 4.Treatment trains leading to drinking water augmentation
- 5.Advanced water treatment leading to water reuse
  - a.Ozone und Advanced Oxidation Processes (AOPs)



- b. Adsorption onto activated carbon (PAC, GAC)
- c. High-pressure membrane processes (Nanofiltration, reverse osmosis)
- 6. Risk assessment and critical control points
- 7. Process trains for seawater desalination; regulatory requirements

**Intended Learning Outcomes:**

After the module lecture series the students are able to understand and remember the concepts and processes for advanced water treatment. Analyzing siting constraints within the urban and natural environment they can evaluate process requirements and conceptually create design water reclamation and reuse facilities as well as seawater desalination plants. In addition, based on the understanding of regulatory and technical requirements, students will be able to analyze critical control points to create schemes for treatment processes optimizations.

**Teaching and Learning Methods:**

The theoretical background and the current guidelines are presented in lectures. Voluntary classroom and Moodle exercises assist the work on problems discussed in the lectures as practical application and preparation for the scientific elaboration.

**Media:**

Powerpoint presentations; Exercises in class and as voluntary homework via Moodle

**Reading List:**

Asano et al. (2007), Water Reuse, John Wiley & Sons, New York.

Edzwald, J. (2011), Water Quality & Treatment, 6th edition, Chapter 16, Drewes & Khan, Drinking Water Augmentation. McGraw Hill, New York.

Wastewater Engineering Treatment and Reuse, Fourth Edition by Metcalf & Eddy, Inc. McGraw-Hill; 4th edition 2003

National Research Council (2012). Water Reuse. The National Academies, Washington, D.C

World Health Organization (2017). Potable Water Reuse Guidelines, Geneva.

**Responsible for Module:**

Jörg Drewes (j.drewes@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Advanced Water Treatment Engineering and Reuse (Vorlesung, 2 SWS)

Drewes J [L], Drewes J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38011: Wastewater Conveyance Systems and Stormwater Management | Bewirtschaftung von Kanalnetzen und Regenwassermanagement

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The written exam (120 min) consists of general questions and calculations.

In the written exam students demonstrate by answering questions the theoretical knowledge of components of sewer systems and rainwater management. By doing calculations they show that they are able to create calculation tasks in sewer systems and rainwater management topics. The answers require own formulations but also multiple choice tests are involved. Focus are calculations.

The use of a calculator and the formulary, given during the lectures, are allowed in the written exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Siedlungswasserwirtschaft Grundmodul (BGU38016)

Siedlungswasserwirtschaft Projektkurs (BGU38020)

#### Content:

Fundamental regulations for sewer systems are learned in this course. Construction and operation of sewer systems are analysed as well as failure in construction and operation. Cost calculation is a big part of the operation of sewer systems. Operating experiences are transferred.

Central and decentral rainwater management are content of the lecture. Laws that are used for building and planning rainwater storage, rainwater reclamation and reuse are discussed. Pollutants in rainwater runoffs and rainwater treatment are shown as well.

**Intended Learning Outcomes:**

After completion of the module, students are able to evaluate the planning and operation of sewer systems, based on simple cost calculations. They can assess holistic concepts to handle rainwater and know treatment processes and options for utilization. After completion of the module students are furthermore able to assess storm water quality and quantity and to propose strategies for rainwater management.

Students can also plan and conduct measures for construction and maintenance of canals and related systems. They can estimate costs for maintenance and are able to conduct simple cost comparison.

**Teaching and Learning Methods:**

The theoretical principles are taught in lectures using presentations as well as the blackboard. To understand the basics taught in lectures, calculation exercises are carried out during the lectures in accordance with the German regulations.

A small excursion to the city drainage systems gives on-site insight into the actual facilities.

**Media:**

Beamer, Powerpoint and board, field trip

**Reading List:**

DIN 1986-100: Entwässerungsanlagen für Gebäude und Grundstücke, 2008

DWA-A 118: Hydraulische Bemessung und Nachweis von Entwässerungssystemen, 2006

DWA –A 117: Bemessung von Regenrückhalteräumen, 2013

DWA-A 166: Bauwerke zur zentralen Regenwasserbehandlung und -rückhaltung, 2013

DWA-A 138: Planung, Bau und Betrieb von Anlagen zur Versickerung von Niederschlagswasser, 2005

DWA-M 153: Handlungsempfehlungen zum Umgang mit Regenwasser, 2007

DWA-M 158: Bauwerke der Kanalisation – Beispiele, 2006

DWA-M 159: Kriterien zur Materialauswahl für Abwasserleitungen und –kanäle, 2005

DWA A-105: Hinweise für die Wahl des Entwässerungsverfahrens (Mischverfahren/ Trennverfahren)

DWA-A 531: Starkregen in Abhängigkeit von Wiederkehrzeit und Dauer, 2012

**Responsible for Module:**

Apl. Prof. Dr. Helmreich, Brigitte; b.helmreich@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Bewirtschaftung von Kanalnetzen und Regenwassermanagement (Vorlesung mit integrierten Übungen, 4 SWS)

Helmreich B [L], Helmreich B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38014: Water and Wastewater Treatment Engineering | Wasserversorgung, Wasseraufbereitung und Abwasserbehandlung

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a written exam of 120 minutes duration.

Through theoretical questions students prove that they understand the individual stages for the elimination of wastewater constituents, the basics of water supply and wastewater management systems as well as necessity and feasibility of wastewater treatment methods, especially of municipal wastewater. Through application-oriented tasks, the students show that they can analyze resource management in the field of wastewater treatment, the performance of related systems, as well as location factors for water technology systems and can critically evaluate various conventional water and wastewater treatment techniques, taking into account urban and natural conditions. They also show that they are able to analyze water treatment problems in a limited time and apply the necessary procedures for the protection of public health, as well as to develop process optimization and solutions for municipal wastewater treatment considering technical and legal regulations.

The tasks often require own formulations, in some cases, multiple choice answers, the focus however being on short calculation tasks. In the exam, limited aids such as lecture handouts and personal notes are allowed. Not allowed are text books, internet and communication among themselves and with third parties.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Siedlungswasserwirtschaft Grundmodul (BGU38016)

Siedlungswasserwirtschaft Projektkurs (BGU38020)

#### Content:

1. Water supply resources and source protection; Character of raw water qualities

2. Regulatory and technical requirements
3. Processes to abstract, treat, store and distribute water for potable supply
4. Structure and organization of public water supply
5. Operation and maintenance of water treatment facilities
6. Character of wastewater, in particular municipal wastewater
7. Regulatory requirements and discharge standards
8. Approaches to treat municipal wastewater/resource recovery facilities
9. Fundamentals of biotechnology and microbial reactions/processes
10. Biological treatment processes
  - a. Activated sludge processes (aerobic, anaerobic)
  - b. Sequencing Batch Reactor (SBR) Technology
  - c. Biofilm reactors
11. Disinfection (chlorine-based; UV irradiation)
12. Biosolids stabilization and energy recovery from waste streams

### **Intended Learning Outcomes:**

After completion of this module course the students are able to:

- conceptually know and understand drinking water and wastewater treatment facilities and processes
- they will be able to apply the knowledge to select proper siting for drinking water facilities considering constraints within the urban and natural environment
- to analyze critical control points and evaluate the appropriate treatment unit processes to protect public health
- to create optimized treatment processes based on regulatory and technical requirements
- to know and understand the need and feasibility of wastewater treatment, with special emphasis on treatment of municipal wastewater
- to apply individual unit processes and operations to remove problematic constituents from wastewater using biological processes for organic and inorganic constituents as well as pathogens
- to analyze resource management related to wastewater treatment
- to conceptually create designs for conventional processes for wastewater treatment and evaluate their performance.

### **Teaching and Learning Methods:**

The module consists of a lecture with integrated exercises. In the lecture, the technical and legal requirements for water and wastewater treatment as well as the theoretical principles of mechanical and biological treatment methods are presented by means of presentations. Furthermore, holistic concepts for water and wastewater treatment are presented. On the basis of the lecture, the methods for water and wastewater treatment are worked into voluntary problem-solving exercises during class exercises and via the Moodle platform.

### **Media:**

Powerpoint presentations; Exercises in class and as voluntary homework via classworks during the lecture and via Moodle

**Reading List:**

Crittenden et al. (2012), Water Treatment Principles and Design , 3rd edition, John Wiley & Sons, New York, 2012

Edzwald, J. (2011), Water Quality & Treatment , 6th edition, McGraw Hill, New York, 2011

McGraw-Hill; 4th edition (2003). Wastewater Engineering Treatment and Reuse

Fourth Edition by Metcalf & Eddy, Inc.

Gujer, Willi (2007). Siedlungswasserwirtschaft. Springer, 3., bearb. Aufl.

**Responsible for Module:**

Prof. Dr.-Ing. Jörg Drewes (jdrewes@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Water and Wastewater Treatment Engineering (Vorlesung mit integrierten Übungen, 4 SWS)

Drewes J [L], Drewes J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38019: Anaerobic Processes and Energy Recovery | Anaerobtechnik und Energierückgewinnung

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The proof of performance is made in the form of a 60-minute written exam with questions on the fundamental understanding as well as small calculation tasks.

The aim of the written exam is the proof that the basic approaches in the field of energy recovery from urban waste streams were understood and different methods can be applied comparatively. Problems need to be analyzed and based on learning outcomes acquired in the course, students have to find and implement solutions in limited time. In the theoretical part, comprehension questions must be answered to basics of anaerobic technology and energy recovery from waste streams. In the calculating part, diverse issues should be analyzed and calculated based on the learning outcomes acquired during the module.

The answers require partly own formulations, partly ticking given single or multiple answers. The focus is on short calculation tasks. For the exam no aids are permitted except for a non-programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering (BGU38014)

#### Content:

- Basics of anaerobic digestion
- Co-digestion
- Power to gas
- Treatment of sewage sludge
  - o Agricultural use and incineration
  - o Recovery of phosphorous

**Intended Learning Outcomes:**

After the successful participation in the course, the students will be able to:

- remember the basic process concepts,
- analyze and evaluate the advantages and disadvantages of the different methods for the specific application,
- and develop simple approaches to calculate and dimension treatment schemes.

**Teaching and Learning Methods:**

The contents of the lecture are taught through practical examples. By means of example tasks in the lecture, possible solutions are discussed and exemplified calculations are performed. During exercise included in the lecture, students apply what they have learned on similar tasks and internalize the approach. The self-study is supported by the provision of further literature in Moodle.

**Media:**

Beamer, black board, literature provided

**Reading List:**

Appels, L., Baeyens, J., Degève, J., Dewil, R., 2008. Principles and potential of the anaerobic digestion of waste-activated sludge. *Prog. Energy Combust. Sci.* 34, 755–781.

Chen, Y., Cheng, J.J., Creamer, K.S., 2008. Inhibition of anaerobic digestion process: A review. *Bioresour. Technol.* 99, 4044–4064.

Kelessidis, A., Stasinakis, A.S., 2012. Comparative study of the methods used for treatment and final disposal of sewage sludge in European countries. *Waste Manag.* 32, 1186–1195.

Roskosch, A., Otto, S., 2014. Technical Guide on the Treatment and Recycling Techniques for Sludge from Municipal Wastewater Treatment with references to Best Available Techniques (BAT). Fed. Environ. Agency Ger.

Wiechmann, B., Dienemann, C., Kabbe, C., Brandt, S., Vogel, I., Roskosch, A., 2013. Sewage sludge management in Germany. Umweltbundesamt, Bonn.

**Responsible for Module:**

Dr.-Ing. Konrad Koch, k.koch@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Anaerobtechnik und Energierückgewinnung (Vorlesung, 2 SWS)

Koch K [L], Koch K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU38021: Industrial Wastewater Treatment and Reuse | Industrieabwasserreinigung und Wiederverwendung

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The proof of performance is made in the form of a 60-minute written exam with questions on the fundamental understanding as well as small calculation tasks.

The aim of the written exam is the proof that the basic principles and approaches in the fields of industrial wastewater treatment, water reclamation and reuse, as well as integrated environmental protection measures are understood in industrial operation and different methods approaches can be applied comparatively. Problems need to be analyzed and based on learning outcomes acquired in the courses of the module students need to find and implement solutions in limited time.

The answers require partly own formulations, partly ticking given single or multiple answers and short calculation tasks. For the exam no aids are permitted except for a non-programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Participation in "Sanitary Engineering and Water Quality Basic Module" (BGU38016) and "Water and Wastewater Treatment Engineering" (BGU38014) is required. General requirement is basic knowledge of wastewater treatment is efficient.

#### Content:

Contents of the lecture are the definition of water flows and complexity of effluents of various industries with mostly organic or inorganic ingredients. Legal regulations, process and production integrated environmental protection, end-of-pipe technology also belong to the content of the lecture as well as mechanical, chemical and physical treatment methods, aerobic and anaerobic biological treatment (special procedures). Using examples from different industries both integrated

environmental protection measures, as well as wastewater treatment and wastewater reuse are described.

**Intended Learning Outcomes:**

Students are able to evaluate possibilities of integrated environmental protection measures and wastewater treatment processes and wastewater reuse in the industry. They know characteristics of industrial wastewaters compared to domestic wastewater. Students know which legal regulations for the treatment of industrial wastewater in Germany are necessary. Students are able to estimate combined methods (physical/ biological) for the elimination of toxic elements.

**Teaching and Learning Methods:**

The theoretical background and the current guidelines are presented in lectures. By means of example from industrial facilities and examples in the lecture, possible solutions are discussed and exemplified calculations are performed. On the basis of lecture notes in Moodle learned content can be repeated and internalized. The self-study is supported by the provision of further literature in Moodle.

**Media:**

Beamer, blackboard, power-point slides

**Reading List:**

Power-point slides as pdf in moodle

**Responsible for Module:**

Helmreich, Brigitte

**Courses (Type of course, Weekly hours per semester), Instructor:**

Industrieabwasserreinigung und Wiederverwendung (Vorlesung, 2 SWS)

Helmreich B [L], Helmreich B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38023: Engineered Natural Treatment Systems | Natürliche Aufbereitungsverfahren

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The proof of performance will be made in the form of a 60-minute written exam. The aim of the written exam is to prove understanding of basics and mechanisms of natural treatment systems and the ability to plan and design simple systems based on natural treatment processes by using existing guidelines. The answers mostly require partly own formulations, but also ticking given single or multiple answers and short calculations will be required. For the exam no aids are permitted except for a non-programmable calculator. The examiner will provide additional documents if needed for the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering

#### Content:

This module deals with processes and application of engineered natural treatment systems. Major abiotic and microbial transformation processes will be discussed in general and with respect to different applications including vertical flow and horizontal flow constructed wetlands, bank filtration and different applications of managed aquifer recharge technology. In addition, students will learn basics on enzymatic processes and reactions. The module also comprises engineering aspects for design and operation of engineered natural treatment systems as well as contents from ongoing research towards optimization of these systems and combinations with other treatment processes for water reuse.

#### Intended Learning Outcomes:

Upon successful completion of this module, students are able

- To describe major mechanisms and key parameters for contaminant removal in natural treatment systems
- To explain microbial and enzymatic processes and their dynamics in natural treatment systems
- To outline design of wastewater treatment with constructed wetlands for small communities based on local parameters
- To characterize methods and applications of bank filtration and groundwater recharge and discuss their potential for application in future water concepts

**Teaching and Learning Methods:**

Lehr- und Lernmethoden:

The module will be taught as a seminar by explaining major content in form of short lectures with integrated discussion. Furthermore, students will work in groups to develop solutions for selected case studies within the seminar. Additional field trips will help to further understand learned contents.

**Media:**

Presentation, group work

**Reading List:**

Will be announced at the beginning of the course.

**Responsible for Module:**

Hübner, Uwe (u.huebner@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Natürliche Aufbereitungsverfahren (Seminar, 2 SWS)

Hübner U [L], Hübner U

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38024: Advanced Water Treatment and Anaerobic Processes | Weitergehende Wasserbehandlung und Anaerobtechnik

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a 120-minute written closed book test consisting of theoretical questions and calculation tasks.

The aim of the theoretical questions is to demonstrate that students understand approaches to typical tasks in fields such as water treatment and anaerobic technology, water reuse and energy recovery from urban residual streams. The students show that they are able to analyse and evaluate different treatment methods and select process approaches (including process concepts for anaerobic technology and energy recovery) for realistic problems. On the basis of practical tasks, they show that they are able to design sites for water reuse as well as estimate the related hazard potential and develop process optimisations using technical guidelines and legal requirements.

Students have to analyse water engineering tasks in a limited time, find and implement suitable solutions. The answers sometimes require own formulations, the focus being however on short calculation tasks.

Except for a non-programmable pocket calculator, no aids are allowed for the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering (or equivalent courses on master's level)

#### Content:

- Introduction, regulatory and technical requirements of water reuse and seawater desalination

- Treatment trains to facilitate non-potable reuse
- Treatment trains leading to drinking water augmentation
- Advanced water treatment leading to water reuse: Ozone und Advanced Oxidation Processes (AOPs), Adsorption onto activated carbon (PAC, GAC), High-pressure membrane processes (Nanofiltration, reverse osmosis)
- Risk assessment and critical control points
- Process trains for seawater desalination; regulatory requirement
- Basics of anaerobic digestion
- Modeling of anaerobic digestion processes
- Treatment of sewage sludge (Introduction, agricultural use and incineration, recovery of phosphorous)
- Pre-treatment for enhanced digestibility
- Co-digestion
- Deammonification and CANDO
- Power to gas

### **Intended Learning Outcomes:**

After completing the module students are able to understand and remember the concepts and processes for advanced water treatment; analyse siting constraints within the urban and natural environment; they can evaluate process requirements and conceptually create design water reclamation and reuse facilities as well as seawater desalination plants. Based on the understanding of regulatory and technical requirements, students will be able to analyze critical control points to create schemes for treatment processes optimizations.

In addition, the students will be able to remember the basic process concepts of anaerobic processes and energy recovery, analyze and evaluate the advantages and disadvantages of the different methods for the specific application and develop simple approaches to calculate and dimension treatment schemes.

### **Teaching and Learning Methods:**

The module consists of two lectures. Theoretical basics as well as current guidelines are presented during the lectures. Approaches for the application of the different treatment methods are discussed in the lectures through practical examples. Exemplary calculations for the design of treatment methods and the assessment of risks are also carried out. In the subsequent exercise, the students apply the presented methods on further tasks. The self-study is supported by the provision of advanced technical literature in Moodle.

### **Media:**

Powerpoint presentations, black board, Exercises in class and as voluntary homework via Moodle

### **Reading List:**

Will be provided via Moodle

### **Responsible for Module:**

Jörg Drewes (j.drewes@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Advanced Water Treatment Engineering and Reuse (Vorlesung, 2 SWS)

Drewes J [L], Drewes J

Anaerobtechnik und Energierückgewinnung (Vorlesung, 2 SWS)

Koch K [L], Koch K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38025: Design and Operation of Wastewater Treatment Plants | Planung und Betrieb von Kläranlagen

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The Examination will consist of a 60 minute written exam.

The aim of the written exam is to prove that students understand fundamentals, tools and guidelines for the design and construction of municipal wastewater treatment plants and are able to reproduce and apply them in a compressed form. Therefore, problems need to be analyzed and based on the learning outcomes in the module, students have to find and apply solutions in limited time.

The answers require partly own formulations, partly ticking given multiple answers. For the exam, documents in paper form will be allowed. The use of electronical devices (except for a non-programmable calculator) and the connection to the internet are not permitted.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Sanitary Engineering and Water Quality Basic Module (BGU38016)

System Design - Urban Water Systems Engineering (BGU38020)

Water and Wastewater Treatment Engineering (BGU38014)

#### Content:

- Basic processes for wastewater treatment, procedures for planning (work phases), announcement and operation
- Conceptual design, dimensioning, design, positioning and location of plants, basics of construction, elements of a wastewater treatment plant
- Supplementary elements, side operating systems, analytics and monitoring
- Field trip to a wastewater treatment plant
- Plant optimization, plant renovation, Special issues



**Intended Learning Outcomes:**

After the module the students are able to design wastewater treatment plants. They can describe the basic methods of wastewater treatment and are able to develop design and plan for a sewage treatment plant according to the principles applied to the work phases 1 to 9 of HOAI. In addition to systems for actual treatment of wastewater, students are also able to name and classify the necessary auxiliary installations of a wastewater treatment plant. Furthermore, students will know the technical regulations and legal requirements and can optimize existing wastewater treatment plants based on these requirements.

**Teaching and Learning Methods:**

The course will be held as lecture series. In addition, the learned content and the practical operation of a plant are further illustrated by the visit of an existing plant.

**Media:**

Powerpoint presentation, exercises during lectures and via moodle

**Reading List:**

Bundesrepublik Deutschland (2013): Honorarordnung für Architekten und Ingenieure (HOAI). Berlin

DIN Normenausschuss Bauwesen (2016): DIN 18205 Bedarfsplanung im Bauwesen. Berlin

DWA (2016): DWA-A 131 Bemessung von einstufigen Belebungsanlagen, Arbeitsblatt. Hennef

**Responsible for Module:**

Hübner, Uwe (u.huebner@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Planung und Betrieb von Kläranlagen (Seminar, 2 SWS)

Hübner U [L], Böhm B, Hübner U

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38028: Water Resource Recovery Process Simulation and Design | Prozesssimulation und Design von Kläranlagen

Version of module description: Gültig ab summerterm 2017

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>67   | <b>Contact Hours:</b><br>23          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Achievement of the course learning outcomes will be assessed through two voluntary mid-term assignments, and a graded final project.

For the final project, students will develop a model of a real-world wastewater treatment system using the dynamic wastewater treatment simulation software package BioWin, and evaluate various options for a major upgrade of the treatment system to meet new discharge regulations. The students' abilities to apply the wastewater treatment theory covered in lectures in the development of treatment system models, perform simulations, analyze and present simulation results in graphical and tabular form, and formulate engineering design recommendations will be evaluated. The final project will also be used to assess students' understanding of, and ability to explain, the role of key water resource recovery processes in achieving treatment goals and their ability to describe the design approaches and operational control parameters for these processes. The first voluntary mid-term assignment will also assess students' abilities to model wastewater treatment processes using BioWin; however, the modeling assignment will be more constrained than for the final project, and the emphasis will be on assessing students' progress in mastering the BioWin platform. Completion of the model development and simulations and preparation of the written report is designed to take 8 to 10 hours.

For the second voluntary assignment, students will work individually or in pairs to develop a modeling tutorial. The students will present background information on the model element being taught and the wastewater treatment process being modeled and will lead their fellow students through the completion of the tutorial. Successful completion of each voluntary course assignment will result in an improvement of 0.3 in the module grade.

#### Repeat Examination:

**(Recommended) Prerequisites:**

Water and Wastewater Treatment Engineering

**Content:**

The course will provide a critical link between the wastewater treatment theory covered in Water and Wastewater Treatment Engineering and the engineering practice of water resource recovery facility process design. Key concepts related to the design and operation of key treatment processes (including activated sludge, nitrification, biological nutrient removal, trickling filters, anaerobic digestion, and/or gravity and membrane solids separation) will be reviewed. The course will also introduce students to a dynamic modeling software package (BioWin). Students will learn how to apply engineering theory to build models of water resource recovery facilities and simulate their performance using BioWin.

**Intended Learning Outcomes:**

Upon successful completion of this module, students will be able to:

- Given the treatment and resource recovery goals for a wastewater flow, develop an appropriate treatment flow scheme and explain the role of each treatment process in achieving the treatment goals.
- Describe the key design approaches and operational control parameters for key water resource recovery processes.
- Use the dynamic simulation software package BioWin to construct models of water resource recovery facilities and perform steady-state and dynamic simulations of their performance for constant and dynamic, respectively, wastewater inputs.
- Generate data tables and graphs using BioWin and effectively describe model development and results in report form.
- Analyze simulation results and formulate engineering design recommendations based on these analyses.

**Teaching and Learning Methods:**

Lectures and active, in-class problem-solving exercises will be used to review key treatment design principles to ensure that all students have the necessary background needed to build meaningful models and perform useful simulations. Hands-on tutorials will be used to teach students how to build models of wastewater treatment systems and perform simulations using BioWin, a dynamic wastewater process simulator that is widely used by engineering consulting firms. Students will also work individually or in pairs to develop tutorials covering additional model functions to facilitate peer learning. Students will complete wastewater treatment and design assignments and a project to develop and facilitate assessment of their modeling abilities and creative problem-solving skills.

**Media:**

Modeling and tutorials using PC

**Reading List:**

Wastewater Engineering, Treatment and Reuse, Fifth Edition, Metcalf and Eddy, Inc. (M&E) by G. Tchobanoglous, F. L. Burton, and H. D. Stensel, ISBN-13: 978-0-07-340118-8

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Prof. Jennifer Becker

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU38030: Statistical-Stochastic Forecasts of the Structural and Operational Status of Drainage Systems | Statistisch-stochastische Prognosen des baulich-betrieblichen Zustands von Entwässerungssystemen**

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The proof of performance is made in the form of a 60-minute written exam with questions on the fundamental understanding.

The aim of the written exam is to proof that the basic principles and approaches in the fields of creating state forecasts for water and drainage systems has been understood and their critical conditions can be identified. Problems need to be analyzed and based on learning outcomes acquired in the courses of the module, students need to find and implement solutions in limited time.

The answers require partly own formulations, partly ticking given single answers. For the exam no aids are permitted except for a non-programmable calculator.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Basic knowledge on the planning of sewer systems, e.g. from participation in the module "Planning of Sewer Systems and Rainwater Management ((BGU38011)).

#### **Content:**

Contents of the lecture is the background to network operation and rehabilitation decision, the basics statistical-stochastic projections, the study methodology for state projections, conducting inspections and assessing the structural and operational channel state, the coding systems for optical inspection of drainage systems, the critical condition of the drainage system. The critical state is modeled by an example using a statistical model based on the Weibull two-parameter

distribution and by stochastic modeling using the Monte Carlo method. After analyzing the test results, planning proposals for sewer rehabilitation measures are derived and a channel state forecast is compiled according to Markov.

**Intended Learning Outcomes:**

After successful participation, students will be able to determine and assess the critical condition of water and drainage systems. From the results they can derive remedial measures and submit planning proposals. They are further able to create channel state forecasts.

**Teaching and Learning Methods:**

Theoretical foundations as well as statistical-stochastic methods are presented and elaborated on the basis of examples. Based on the lecture materials provided in Moodle, what has been learned can be repeated and internalized.

**Media:**

Beamer, blackboard, power-point slides

**Reading List:**

power-point slides and additional literature will be provided as pdf in moodle

- Müller-Gronbach T., Novak E., Ritter K.: Monte Carlo – Algorithmen, Springer-Verlag, Berlin Heidelberg 2012.
- Porth M.: Wasser, Energie und Umwelt, Aktuelle Beiträge aus der Zeitschrift Wasser und Abfall I, Springer-Vieweg, 2017.
- Raganowicz A.: Nutzen statistisch-stochastischer Modelle in der Kanalzustandsprognose, Springer-Vieweg, 2017.
- Stein D., Instandhaltung von Kanalisationen, diverse Auflagen, Ernst & Sohn, Berlin 1999.

**Responsible for Module:**

Uwe Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**

Statistisch-stochastische Prognosen des baulich-betrieblichen Zustands von Entwässerungssystemen (Vorlesung, 2 SWS)

Hübner U [L], Raganowicz A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38031: Sanitation in the Global South | Sanitäre Versorgung im globalen Süden

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination will be based on a final project report (60%) and presentation (40%).

For the final project, students will write a report on the case study area, a small town in northern India, applying content approaches learned during the class to create a holistic sanitation system for the town and evaluate its practical feasibility. Content and approaches include demonstrating (i) understanding the need for sanitation (based on health aspects and the Sustainable Development Goals), (ii) analysis and planning methods on sanitation projects (involving stakeholders and planning concepts such as CLUES and CLTS), (iii) creating sanitary system designs; and (iv) evaluating management and financing methods (taking into account classic and innovative financing methods). By additionally presenting the results of their final project, students demonstrate that they can explain their proposed design and ideas in a structured and understandable manner to a technical audience.

Each student's grade will be determined by his/her individual contribution to the final project report and presentation, which will both be worked on in teams of 4 students. Particular emphasis will be placed on logical structure and the applicability of the design to the case study area in evaluating the final project reports and presentations.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Engineered Natural Treatment Systems
- Water and Wastewater Treatment Engineering
- Wastewater Treatment

#### Content:

- Identifying negative impacts of inadequate sanitation/motivation for good sanitation

- Identifying stakeholders and delineation of methods for behavioral change
- Developing an holistic engineered sanitation system
- Applying planning strategies, such as community led urban environment sanitation planning (CLUES) and community led total sanitation (CLTS)
- Stating concepts for financing sanitation projects
- Investigating and applying sanitation analysis and planning tools

### **Intended Learning Outcomes:**

Upon completion of this project course students will be able to:

- Identify consequences of inadequate sanitation & describe the complexity and challenges of urban sanitation in various settlements (urban/peri-urban/rural)
- Summarize the Sustainable Development Goals (SDGs) and describe current international aid framework in the global context
- Identify stakeholders involved in successful sanitation planning and list different incentives for behavioral change
- Contrast different planning concepts such as CLUES and CLTS and apply those concepts on the case study area
- Apply urban sanitation analysis and planning tools to the case study focus area and develop case specific engineering solutions
- Distinguish between classical and innovative funding models

### **Teaching and Learning Methods:**

This course is designed as an independent elective course. During the lecture, students will be primarily taught about social, technological and management aspects of successful sanitation projects in the Global South. Additional teaching support will be provided by external lecturers with professional experience in the international development field. Students will receive learning materials and literature to expand their knowledge, in addition to further information regarding the case study area. Project work will be conducted in teams of 4 students. Students will have the opportunity to discuss questions or approaches with the teaching team during weekly tutorial sessions focused on content taught in the class the same week, prior to submission of the final report. The results of the final report will then be presented to the teaching team.

### **Media:**

ppt presentations

### **Reading List:**

Gensch, R.; Jennings, A.; Renggli, S.; Reymond, P. Compendium of Sanitation Technologies in Emergencies; 2018.

United Nations Children Fund; World Health Organisation. Progress on Drinking Water, Sanitation and Hygiene; 2017.

Lüthi, C.; Morel, A.; Tilley, E.; Ulrich, L. Community-Led Urban Environmental Sanitation Planning (CLUES); Eawag-Sandec, WSSCC, UN-HABITAT, 2011.



Tilley, E.; Ulrich, L.; Lüthi, C.; Reymond, P.; Zurbrügg, C. Compendium of Sanitation Systems and Technologies; 2008.

**Responsible for Module:**

Uwe Hübner [u.huebner@tum.de](mailto:u.huebner@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38033: Planning the Urban Water-Energy-Food Nexus | Urban Water-Energy-Food Nexus Planung

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The proof of performance will be made in the form of a project. This project will be conducted in small groups of students, whereby an individual thematic focus will be defined for each student. The aim of the project is to prove understanding of basics of different technical and non-technical components of integrated urban planning and their application in the development of simple urban planning projects. The project requires an intensive analysis of the thematic focus and thus the students prove an in-depth understanding of these components and the ability to combine these in an innovative way. This understanding will be proven using planning, geographic information systems-based, calculatory and modeling methods. At the end of the course, the students prove their ability to present and explain their concepts, approaches and methods in front of an expert audience through a presentation and a short discussion.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering (BGU38014)

#### Content:

This module deals with concepts, approaches and methods for integrated urban planning. Good practice examples are discussed in general terms before learning to apply these to a concrete case study city. In addition, students will learn about concepts and driving forces of the topics urbanization, globalization, climate change, environmental challenges, sustainability including UN Sustainable Development Goals (SDGs) as well as current research on water reclamation with resource recovery.

**Intended Learning Outcomes:**

Upon successful completion of this module, students are able

- To know and explain contextual challenges and existing concepts, approaches and methods to address these
- To understand and explain international development dynamics and implications for natural resources consumption patterns
- To choose and compare technical and non-technical components of integrated urban planning
- To evaluate technical and non-technical components of integrated urban planning in terms of their context
- To develop innovative concepts and combinations of these components

**Teaching and Learning Methods:**

The module will be taught as a lecture with seminar parts. It will explain major content in form of lectures with integrated discussion. Furthermore, students will work in groups to develop solutions for selected case studies within the seminar. Additional field trips will help to further understand learned contents.

**Media:**

Presentations, group work

**Reading List:**

Hoff, H. (2011). Understanding the Nexus. Background Paper for the Bonn2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm, pp. 52.  
Gondhalekar, D. and T. Ramsauer (2017). Nexus City: operationalizing the urban Water-Energy-Food Nexus for climate change adaptation in Munich, Germany. Urban Climate 19: 28–40, DOI: 10.1016/j.uclim.2016.11.004 [OA]

**Responsible for Module:**

Daphne Keilmann-Gondhalekar

**Courses (Type of course, Weekly hours per semester), Instructor:**

Urban Water-Energy-Food Nexus Planung (Vorlesung, 2 SWS)

Keilmann-Gondhalekar D [L], Keilmann-Gondhalekar D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU40035: Environment and Land Use Planning | Umwelt- und Landnutzungsplanung

Version of module description: Gültig ab summerterm 2020

|                                  |                            |                                  |                                      |
|----------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6            | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulleistung wird in einer schriftlichen Prüfung in Form einer Klausur erbracht. Ohne Hilfsmittel sollen die Studierenden Instrumente und Planungsprozesse der Umweltplanung wiedergeben und in eigenen Formulierungen die komplexen Zusammenhänge zwischen Umweltplanung und Bodenpolitik beim nachhaltigen Umgang mit Grund und Boden erläutern. Instrumente und Prozesse sollen in Fragen zu nationalen und internationalen Beispielfällen angewandt und auf ihre Wirksamkeit hin bewertet werden können. Die Studierenden sollen in eigenen Formulierungen Hintergründe, Aufgaben und Ziele nachhaltiger Landnutzungsplanung wiedergeben und die komplexen ökonomischen, ökologischen und eigentumsrechtlichen Zusammenhänge bei der Planung und Gestaltung von Landnutzung erläutern können. Beide Teilleistungen gehen zu gleichen Teilen in die Gesamtnote ein.

Aktueller Hinweis angesichts des eingeschränkten Präsenzbetriebs auf Grund der CoViD19-Pandemie: Sofern die Rahmenbedingungen (Hygiene-, Abstandsregeln etc.) für eine Präsenzprüfung nicht vorliegen, kann gemäß §13a APSO die geplante Prüfungsform auf eine online-gestützte schriftliche oder mündliche Fernprüfung umgestellt werden. Die Entscheidung über diesen Wechsel wird möglichst zeitnah, spätestens jedoch 14 Tage vor dem Prüfungstermin durch die Prüfungsperson nach Abstimmung mit dem zuständigen Prüfungsausschuss bekannt gegeben.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Modul Räumliche Planung und Verwaltungsrecht BGU 40032
- Modul Landmanagement für Geographen BGU 40033
- Modul Bodenordnung und Grundstückswertermittlung BGU 40034

-- Modul Kommunal und Landentwicklung BV 400006

**Content:**

Umweltplanung und Bodenpolitik

A) Grundlagen, internationale Zusammenhänge

- Begriffsdefinitionen
- Government und Governance
- Situation and challenges of land tenure and land policy in developing countries
- Sustainable Development Goals und der Aspekt Boden

B) Umweltplanung und Bodenpolitik in der Praxis in Deutschland

- strukturschwache Regionen, Integriertes Ländliches Entwicklungskonzept (ILE), Gemeindeentwicklung
- Stadtumbau, Soziale Stadt, Kompakt Urban Grün
- Verringerung des Flächenverbrauchs
- Konzepte zur Mehrfachnutzung von Land
- Erneuerbare Energien im ländlichen Raum – Chancen und Risiken
- Hochwasserschutz

Landnutzungsplanung:

- Landschaften in Mitteleuropa und die Art und Weise ihrer Nutzung
- nachhaltige Formen der Landnutzung und langfristige Sicherung der Ökosystemdienstleistungen von Landschaft
- Hintergründe, Aufgaben und Leitgedanken der Landnutzungsplanung in folgenden Kapiteln:
  1. Landschaftsplanung oder Landnutzungsplanung?
  2. Geschichte der Landnutzung in Mitteleuropa und ihre ökologische Auswirkungen
  3. Ökologische Grundlagen der Landnutzungsplanung
  4. Bausteine der Landnutzungsplanung
    - a. Stoff- und Energiestrommanagement
    - b. Projektentwicklung und Kommunikationsmanagement
    - c. Ökonomische Strategien
  5. Landnutzung mit unternehmerischen Menschen gestalten

**Intended Learning Outcomes:**

Nach der Teilnahme an der Modulveranstaltung kennen die Studierenden Instrumente und Prozesse der Umweltplanung und deren unterschiedliche nationale und internationale Einsatzfelder. Sie verstehen die aktuellen weltweiten Herausforderungen im Umgang mit Grund und Boden, erfassen den Zusammenhang zwischen Bodenpolitik und Umweltplanung und sind in der Lage, die Vor- und Nachteile bestimmter Planungsmethoden zu bewerten.

Sie kennen die ökonomischen und ökologischen Anforderungen an die Landnutzungsplanung, deren Aufgaben und Leitgedanken. Sie begreifen die Bedeutung nachhaltiger Formen der Landnutzung auf dem Hintergrund von Klimawandel, Flächenverbrauch, Sicherung der weltweiten Ernährung und Erzeugung von Energie und können die komplexen Zusammenhänge auch auf dem Hintergrund der Eigentumsstrukturen diskutieren.

**Teaching and Learning Methods:**

Lehrformat: Vorlesung

Methoden: interaktiver Vortrag mit Präsentation zur Vermittlung von Wissen. Die Lehrmethoden sind auf die Lernaktivitäten Materialrecherche, Studium von Literatur und Auswendiglernen ausgerichtet.

Gastdozenten vermitteln den Studierenden Einblick in die praktischen Einsatzfelder und Spezialwissen über die Wirksamkeit der Instrumente.

**Media:**

- Power Point Präsentation
- Vorlesungsskript

**Reading List:**

**Responsible for Module:**

Florian Siegert, [florian.siegert@tum.de](mailto:florian.siegert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Landnutzungsplanung (Vorlesung, 2 SWS)

de Vries W [L], Henger E ( Bendzko T )

Umweltplanung und Bodenpolitik (Vorlesung, 2 SWS)

de Vries W [L], Jacobsen C ( Hölzel M )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU41020: Fluid Mechanics and Transport Mechanisms | Fluidmechanik und Transportmechanismen

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcomes are checked by a written exam (90 min.).

Within this exam the students show, that they are able to solve calculation problems applying the classical relations of fluid mechanics, e.g. application of the Navier-Stokes equations, momentum theorem or the law of the wall in turbulent boundary layers.

Furthermore the students proof, that they are able - using given physical or fluid mechanical systems - to determine a set of similarity numbers and the describing time scales, to characterize transport phenomena in turbulent flows, apply boundary conditions to momentum and mass transport problems, estimate in an engineering manner the distribution of pollutants for different emission and transport scenarios and evaluation propagation processes in atmosphere and free surface flows.

Allowed aids are a handwritten A4 sheet (front and back) and a non-programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- module Hydromechanics (BV00013) or equivalent
- knowledge in vector and tensor calculus.

#### Content:

- continuum hypothesis
- calculus
- kinematics
- equations of motion in differential form
- scaling laws, time constants and dimensional analysis
- laminar and turbulent boundary layers

- repetition of the engineering fundamentals of fluid mechanics
- advection, diffusion and conservation equations
- propagation (diffusion and advection) of instantaneous and continuous point sources
- treatment and specification of boundary conditions
- closures for turbulent transport

### **Intended Learning Outcomes:**

On successful completion of this module the students are able to:

- explain the utilization of the concept of a continuum in fluid mechanics
- understand the concept and the structure of a (turbulent) boundary layer
- apply the Navier-Stokes equations for the incompressible case, the law of wall for turbulent flows to selected flow cases
- apply boundary conditions for momentum and mass transport problems
- characterize flow fields with the help of flow lines (stream lines, path lines, streak lines) and by the strain rate tensor and the rotation rate tensor
- characterize transport phenomena in turbulent flows
- determine a set of non-dimensional parameters for a given physical system
- determine the governing time constant of simple fluid mechanical systems and transport phenomena
- determine in an engineering manner the pollutant distributions for different emission and transport scenarios
- determine forces, pressure and velocities that act on the boundaries of a flow domain by means of simple tools within a short time
- evaluate propagation processes in atmosphere and free surface flows

### **Teaching and Learning Methods:**

The module is based on a classical lecture. The main content is derived on the blackboard, supported by slides and discussed with students. Examples are shown to underline the importance and the applications of the discussed relations. Further the students are encouraged to research literature before and after classes to compare different ways of derivation and presentation. There is voluntary homework. This gives the students the chance to apply their knowledge to small problems and check their learning progress periodically during the semester. There is also a voluntary seminar (90min.) for the Fluid Mechanics part. There the students can solve the homework sheets in small groups and post-process the lecture. The discussion of the students is moderated and supported by a lecturer.

### **Media:**

black / white board, presentation slides, videos, exercise sheets, e-learning

### **Reading List:**

- Course script, presentations and assignments available to participants on elearning platform
- G. K. Batchelor. An Introduction to Fluid Dynamics. Cambridge University Press, 1967.
- I. G. Currie. Fundamental Mechanics of Fluids. McGraw-Hill, New York, 1974.



P. K. Kundu and I. M. Cohen. Fluid Mechanics, Third Edition. Elsevier, Amsterdam, 2004.  
R. L. Panton. Incompressible flow. John Wiley and Sons, Inc, Hoboken, third edition, 2005.  
D. J. Tritton. Physical Fluid Dynamics. Van Nostrand Reinhold, New York, 1977.  
M. van Dyke. An Album of Fluid Motion. Parabolic Press, Stanford, California, 1982.  
S. B. Pope. Turbulent flows. Cambridge University Press, Cambridge, 2000.  
H. Tennekes and J. L. Lumley. A first course in turbulence. The MIT Press, Cambridge, Massachusetts, 1972.

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Fluid Mechanics and Transport Mechanisms (Vorlesung, 4 SWS)

Manhart M, Sakai Y, Quosdorf D

Seminar zur Fluidmechanik (Seminar, 2 SWS)

Quosdorf D, Unglehart L, Brosda J, von Wenczowski S, Sakai Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU44014T2: Computation in Engineering II | Computergestützte Berechnungsverfahren in den Ingenieurwissenschaften II

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a 90-minute exam and a piece of work in the form of an exercise in which the studentthe programming knowledge of the students.

Within the scope of the study performance the students have to program their plugin for the CAD program Rhino independently and present the final result. The acceptance of this programming task takes place through a 15-minute one-on-one interview, which must be passed. The independent programming task and the associated final discussion should prove that the students have understood the essential aspects of how to develop a complex program in modern C++. In addition, the generic concepts should be able to reproduce modern languages.

The exam proves that frequently occurring topics in the field of engineering informatics, such as spline-based geometry representation or the iterative solution of equation systems, can be applied. No aids are permitted in the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Successful completion of the course: Computation in Engineering I (BGU44013T2)

#### Content:

- involved concepts of object oriented modeling such as patterns.
- transferring UML to C++ (classes, structures, templates, inheritance, graphic user interfaces)
- numerical methods for the iterative solution of large equation systems
- "Computational Steering" for the interactive solution of the Laplace-equation
- mathematical and geometrical concepts for the representation of curves and surfaces (Splines, B-Splines, NURBS) as well as their realizations within object oriented programs.

- introduction into the standard template library of C++
- advanced programming techniques in C++

**Intended Learning Outcomes:**

After a successful participation, the student is in the position to,

- develop and implement advanced, object oriented programs and data structures in C++
- implement splines, B-splines und NURBS in C++
- understand the mathematical principles behind iterative solutions of equation system and implement them accordingly

**Teaching and Learning Methods:**

The module consists of a lecture with integrated exercise. The methods developed in the lecture will be implemented in C++. Some tasks for the learning control are programmed in the lecture directly after the taught material or are given home as a voluntary exercise. The solutions will be presented and discussed in the following week.

The lecture takes place in the computer rooms of the faculty, so that own notes can be inserted immediately into the online available lecture material and the exercise material can be converted at own program examples. All presentation documents, tasks, solutions etc. can be downloaded from the website with the handwritten supplements of the respective lecturer (tablet PC) after the respective course to support self-study.

**Media:**

PowerPoint as well as the white board are utilized.

**Reading List:**

Daoqi Yang: C++ and object-oriented numeric computing for Scientists and Engineers, Springer-Verlag 2001. A sufficient number of copies is in stock at the university library. Additionally, print out copies of the manuscript and lecture notes are available from the lecturer.

**Responsible for Module:**

Christoph Ertl (christoph.ertl@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Computation in Engineering II (Vorlesung mit integrierten Übungen, 3 SWS)

Kollmannsberger S, Holla V, Hug L

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46021: Hydro Power and Energy Storage - Project Work | Wasserkraft und Energiespeicherung - Projektarbeit

Version of module description: Gültig ab winterterm 2013/14

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>70   | <b>Contact Hours:</b><br>20          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Each group will describe the results of their planning in a report of approx. 50 pages and will present their work in a 15 minutes presentation to the other participants of the course.

This format will allow the students to prove that they are capable of completing the individual planning steps in a correct manner and that they are capable of collecting and compiling the necessary data as well as of valuating the plant they have planned in technical and economical respects. Furthermore it will be verified if the students are able to describe their results in a systematic manner in writing and drafting, and if they are capable of presenting their work in front of a competent audience in a condensed form. The final grade is composed of the point score given for the report (weight 66%) and the point score given for the team presentation (weight 33%).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Course "Hydro Power and Energy Storage"

#### Content:

In the course of the project work, a complete planning of a Hydro Power Station is performed:\*

- processing of the hydrological data
- potential analysis for a chosen plant concept
- choice of suitable turbines and generators
- dimensioning und draft planning of the civil engineering structure
- layout and dimensioning of a fish pass for the site specific target fish
- compilation of a power plan
- economic analysis

- draft representation of the planned plant

### **Intended Learning Outcomes:**

After successful completion of the course, the students are able to

- conceive and detail a conception for a hydro power plan
- After successful completion of the course, the students are able to
- assess the hydraulic potential of a hydro power site
  - conceive and detail a conception for a hydro power plant
  - perform the main steps of the technical planning of a hydro power plant themselves
  - acquire and process the necessary data
  - dimension the planning and draft the plant
  - evaluate the planning in respect to the expected annual production and the economic feasibility
  - analyse the planning of a hydro power plant
  - judge/evaluate the planning of a hydro power plant
  - describe planning results in a systematic way and to present them in front of a competent audience.

### **Teaching and Learning Methods:**

- short lectures giving an introduction into the separate sub-tasks
- discussion of the methods suggested
- groups of 4 students elaborate a planning pursuing different solutions.
- independent work with support if needed (consultation hours)
- project report and project presentation by each group

In this way students gain a profound insight into the methods required, by working in small groups they learn to directly apply them, while they have the possibility to get hands-on help, if needed.

### **Media:**

### **Reading List:**

### **Responsible for Module:**

Wilfried Dr. Knapp (wilfried.knapp@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46022: Hydraulics in Water Engineering | Wasserbauhydraulik [HE]

Version of module description: Gültig ab winterterm 2022/23

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written exam (60 minutes, open book, allowed tools: notes, print medias (books, printed slides...), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

Concerning the practical tasks, the students show that they are able

- To precisely explain the design of hydraulic structures (e.g. weirs, dams) as well as the corresponding operating facilities and to design and assess hydraulic structures using calculations in a solution-oriented manner.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Bachelor's level knowledge in hydraulic engineering, e.g.

- "Basic Module Hydraulic and Water Resources Engineering"
- "Supplementary Module Hydraulic and Water Resources Engineering"

or:

Elective Course for other students.

#### Content:

The module provides in-depth knowledge of principles, methods and technologies for calculation and management of hydraulic engineering as well as hydromorphology.

- Fundamentals of hydraulics
- Normative regulations
- functionality, design and construction of hydraulic structures such as inlet structures, transport structures, outlet structures, energy dissipation structures, surge tanks
- danger to hydraulic structures e.g. cavitation, log jam, scour, vortex formations

- Discussion of dynamic loads, river diversions, construction process and safety concepts
- current examples will show actual facilities with their special problems and solution strategies
- typical design questions and calculations in hydraulic engineering
- one-day excursion to typical hydraulic structures in the pre-alpine/alpine area, on-going hydraulic engineering projects or constructions sites

**Intended Learning Outcomes:**

After successful participation in the module, students will be able

- To design hydraulic structures such as weirs, dams and water supply structures in accordance with safety and normative regulations with regard to their hydraulic conditions
- To identify possible dangers to hydraulic structures and options how to avoid them
- To understand and apply modeling techniques and calculations in hydraulic engineering

**Teaching and Learning Methods:**

- lecture style
- practical examples
- coordinated moodle tests (voluntary)

**Media:**

- PowerPoint presentations with film sequences and computer animations
- blackboard exercises
- moodle tests (voluntary)
- lecture notes in moodle

**Reading List:**

see lecture notes

**Responsible for Module:**

Antonia Dallmeier (antonia.dallmeier@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Wasserbauhydraulik (Vorlesung, 2 SWS)

Reisenbüchler M, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46026: Alpine Hazards | Alpine Naturgefahren [Ri+Kr]

#### *Alpine Hazards*

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination is a written, closed book test of 120 minutes duration. It consists of theoretical questions, practical tasks and calculations. Only a simple scientific calculator and a dictionary are allowed aids.

In the exam, the students demonstrate by answering theoretical questions that they can explain the main processes in alpine watersheds and analyse them concerning the flows of water, debris, the influence on land mass movements and the resulting hazard potential. Furthermore, they show that they understand the working mechanisms of measures for hazard mitigation in mountainous regions. On the basis of practical examples, they show that they can analyse realistic situations and apply mitigation measures in targeted strategies for alpine hazards. Through calculation tasks they prove that they can assess the quantitative aspects of the hazard side and the measure side.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Basic knowledge in Geology and Water Management.

#### **Content:**

Part 1: "Water Management in Mountain Regions"

The students get an introduction on the objectives and means of protective watershed management in alpine regions. The processes in natural landscapes, the relevant influencing factors on runoff and debris flow, the alpine water balance and relevant information sources for planning are outlined. On basis of this fundamental aspects the development of protection concepts, including strategies, requirements and boundary conditions are explained.



Finally the preventive measures with focus on constructional aspects like hydraulic and biological engineering, the management of alpine protective forest and measures for avalanches control as well as aspects of regional planning are presented and discussed.

## Part 2: "Process analysis, Modelling and Mitigation of Alpine Hazards"

The lecture will introduce process understanding of gravitational, nival, glacial and periglacial Alpine Hazards in dynamically changing mountain environments. This includes physical and mechanical aspects of process understanding and stochastic descriptions of magnitude and frequency patterns. On basis of this profound understanding, we will introduce benchmark approaches of how to model and anticipate selected gravitational, nival, glacial and periglacial Alpine Hazards.

These approaches will be evaluated with respect to the presently observed and anticipated Environmental Change in Alpine regions. This will be integrated into the development of sustainable adaptation and mitigation strategies in dynamic Alpine Environments. Best practice examples from different mountain environments will be assessed in a final step.

### **Intended Learning Outcomes:**

After a successful participation in the module the students are able to:

- understand the fundamental natural processes in alpine watersheds,
- understand the main issues in water and debris flow management
- understand the full range of gravitational, nival, glacial and periglacial Alpine Hazards in dynamically changing mountain environments
- analyse the relevant strategies and tools for protection works against alpine hazards
- apply scientific and practical strategies for process understanding, anticipation and mitigation of Alpine Hazards

### **Teaching and Learning Methods:**

The module consists of a lecture series. The theoretical framework of processes and dynamics of alpine hazards will be presented in the lecture. Practical Examples illustrate strategies and measures for the anticipation and mitigation of hazards. Furthermore, students are encouraged to study scientific literature in order to enrich the discussion of the issues. In class exercises, selected examples are calculated and distinct quantitative tasks are shown.

### **Media:**

Blackboard work and PowerPoint presentation.

### **Reading List:**

Script and PowerPoint slides provided from lecturers.

### **Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Prozessanalyse, Modellierung und Vorbeugung/Schutzmaßnahmen für Alpine Naturgefahren  
(Vorlesung, 2 SWS)

Krautblatter M, Rimböck A, Scandroglio R

Water Management in Mountain Regions (Vorlesung, 2 SWS)

Rimböck A ( Fuchs Y ), Fuchs Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU46028: Mathematical Modeling of Hydrodynamics and Water Quality in Coastal Regions | Mathematische Modellierung der Hydrodynamik und Wasserqualität in Küstengebieten [COASTAL]**

Version of module description: Gültig ab winterterm 2013/14

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Written examination (Duration 60 min); the content and degree of difficulty of the written examination are similar to the exercises.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

The students should know the basics on applied hydromechanics or fluid mechanics.

#### **Content:**

1.INTRODUCTION. Coastal discharges: main types (wastewater, thermal and desalination plants discharges), their characteristics and environmental impacts-pollution. General methods for coastal discharging. Near and far field models. Environmental standards and regulatory criteria.

2.DESIGN OF COASTAL OUTFALLS. Mixing phenomena. Environmental and hydraulic design of coastal outfalls. Simple design examples.

3.HYDRODYNAMIC MODELING. Hydrodynamic shallow water equations; boundary conditions and solution. Simple exercises.

4.WATER QUALITY MODELING. Water quality equations (extended advection-diffusion equation with source terms due to physical, chemical and biological processes); boundary conditions and solution. Simple exercises.

5.REAL LIFE APPLICATIONS. Common near and far-field models for coastal waters (including commercial codes) and applications in real cases.

**Intended Learning Outcomes:**

After successful completion of the course the students are able to (1) know the main characteristics of discharge systems for wastewater, thermal and desalination plants discharges, (2) perform the design of discharge systems using (i) Excel and (ii) well-known commercial codes, (3) understand the use of mathematical models to describe the hydrodynamics and water quality in coastal regions, (4) develop simplified versions of these models using Excel, and (5) know how to apply computer codes for these models in real cases.

**Teaching and Learning Methods:**

The lectures are performed interactively with presentations and calculations. Real cases are presented in the classroom and are critically discussed with the students. There are 3 simple obligatory homework exercises that are given to the students. The students form groups of 2 and are expected to solve the exercises and turn them in; then, these are corrected and returned to them.

**Media:**

Presentations on the blackboard; Power Point presentations; calculations in PCs using Excel and computer codes.

**Reading List:**

Stamou, A. (2014). Mathematical Modeling of Hydrodynamics and Water Quality in Coastal Regions, Notes, TUM.

**Responsible for Module:**

Dr. Franz Zunic (franz.zunic@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Mathematical Modeling of Hydrodynamics and Water Quality in Coastal Regions (Vorlesung, 2 SWS)

Bui M [L], Bui M, Stamou A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46030: Ecological Modeling of Surface Waters | Ökologische Modellierung für Oberflächengewässer [ANNA]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Der Leistungsnachweis wird durch eine schriftliche Prüfung (60 min) am Ende des Semesters erbracht, aus welcher sich die Note für das Modul ergibt.

Dabei soll nachgewiesen werden, dass die Studierenden die wesentlichen Aspekte der spezifischen Aufgabenstellung aus den Bereichen Gewässer / Strömungsvorgänge / Ökologie / Habitatmodellierung verstanden haben und anwenden können.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bachelor Degree in Civil or Environmental Engineering.

#### Content:

1. INTRODUCTION. Basic definitions. The significance of ecological models within the implementation of the Water Framework Directive (WFD) with examples.

2. CONCEPTS OF ECOLOGICAL MODELING FOR SURFACE WATERS. Components of an ecological model. Processes and their mathematical description. The main steps of the procedure of ecological modeling.

3. TYPES OF ECOLOGICAL MODELS. Overview of models with examples; advantages and disadvantages.

4. EXAMPLES OF SIMPLE ECOLOGICAL MODELS. Organic pollution in a river; eutrophication in a lake; habitat modeling in a river; and others. Exercises using EXCEL.

5. REAL LIFE APPLICATIONS.

**Intended Learning Outcomes:**

After successful completion of the course the students are able to (1) know the main characteristics of ecological models and their application, (2) realize the potential of application of ecological models as management tools, (3) understand the use of ecological models to deal with pollution problems and pressures within the implementation of the WFD, (4) develop simplified versions of these models using Excel, and (5) know how to apply computer codes for these models in real cases.

**Teaching and Learning Methods:**

The lectures are performed interactively with presentations and calculations. Real cases are presented in the classroom and are critically discussed with the students. There are 3 simple obligatory homework exercises that are given to the students. The students form groups of 2 and are expected to solve the exercises and turn them in; then, these are corrected and returned to them.

**Media:**

Presentations on the blackboard; Power Point presentations; calculations in PCs using Excel and computer codes.

**Reading List:**

1. Fath, B. and Jorgensen, S. E. (2011). Fundamentals of Ecological Modelling, Volume 23, Fourth Edition: Applications in Environmental Management and Research (Developments in Environmental Modelling), Elsevier; <http://www.ebooks-share.net/fundamentals-of-ecological-modelling-volume-23-fourth-edition-applications-in-environmental-management-and-research-developments-in-environmental/>.
2. European Commission European Commission (2012). Indicators and Methods for the Ecological Status Assessment: Linkages between Chemical and Biological Quality of Surface Waters, Joint research Centre; <http://www.amazon.de/Indicators-Methods-Ecological-Status-Assessment/dp/3845456914>.
3. Socolofsky, A. and Jirka, G. (2002). Environmental Fluid Mechanics, Part I: Mass Transfer and Diffusion, Lectures, Institute for Hydromechanics, KIT; [http://www.ifh.uni-karlsruhe.de/lehre/envflu\\_I/Course\\_script/course\\_script.htm](http://www.ifh.uni-karlsruhe.de/lehre/envflu_I/Course_script/course_script.htm).
4. Stamou, A. (2014). Ecological modeling of surface waters, TUM (in preparation).

**Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Ecological Modeling of Surface Waters (Vorlesung, 2 SWS)

Bui M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46032: Hydraulics in Water Engineering Laboratory | Laborübung Wasserbauhydraulik [HWEL]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>50   | <b>Contact Hours:</b><br>40          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

- Moodle short-test (general questions): admission requirement, not graded
- Laboratory report: weighting 40%
- Presentation of results (with discussion for presence): weighting 60%

The short test ensures that the students have the necessary basic knowledge of the experimental topics.

In the laboratory report, the experimental results are documented.

In the presentation of the results for selected topics, it is to be demonstrated that the students have the required deeper understanding.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Hydraulic Engineering (recommended)
- Basic Module for hydraulic engineering and water management (recommended)
- Supplementary Module for hydraulic engineering and water management (recommended)

#### Content:

In the lecture "Hydraulics in Water Engineering" of the Master's degree programmes "Civil Engineering" and "Environmental Engineering", various complex flow conditions are dealt with, which hydraulic engineers are frequently confronted with in practice.

By illustrating these hydraulic processes in a physical model, students can gain a better understanding and at the same time be introduced to the practical use of measuring instruments and the evaluation of measurement data.

The following topics are covered:



- efficiency of weirs
- influence of weir pillars on the efficiency of weirs
- pressure profile on the weir shape
- characteristics of flap gates
- piano key weirs
- shaft spillway, side channel and chutes
- deep outlets
- bottom outlets
- stilling bassins
- surge chambers and water hammer
- cavitation

**Intended Learning Outcomes:**

After successful completion of this module, the students have a deep understanding of the complex hydraulic problems dealt with and can reliably work on them in their further professional life.

**Teaching and Learning Methods:**

- Introduction lecture (online via Zoom)
- one week of supervised exercises at the Hydro Lab in Obernach: measurements on the 8 subjects on physical models (each topic ½ day, in small groups), alternatively videos of the tests ! free accommodation in VAO's guest house for the duration of the course !
- evaluation and presentation of the results

**Media:**

Script, table work, exercise sheets, PowerPoint, movies

**Reading List:**

see lecture notes

**Responsible for Module:**

Dr.-Ing. Richard Huber (richard.huber@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Laborübung Wasserbauhydraulik (Übung, 3,5 SWS)

Huber R [L], Huber R, Scherbaum S, Schlagenhauser M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU46033: Laboratory and Field Exercises at the Oberrach Lab | Modelltechnische und flussbauliche Übungen an der Versuchsanstalt Oberrach [VAO\_2016]** *Block Course VAO*

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                             |
|--------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Discussion, presentation (information on individual knowledge level in group work, application of acquired knowledge to project examples), report, aids allowed

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basic and supplementary module hydraulic engineering and water management or corresponding Bachelor courses

#### **Content:**

Five-day block course + report

1 day theory: Fundamentals of hydraulic engineering modeling experiments, presentation of the current model tests in Oberrach.

4-day practice: Carrying out experiments on current hydraulic engineering models (measuring, documenting, evaluating and evaluating as well as presenting and discussing the results).

Detailed report on the model projects and the results obtained.

#### **Intended Learning Outcomes:**

After passing this course, students are able:

- to apply by means of practical work with running water in-depth hydrological knowledge to examples.
- to understand and successfully deal with questions of current hydraulic engineering projects.

**Teaching and Learning Methods:**

Lectures on the preparation of the necessary basics, guided tour through the experimental facilities with the current hydraulic engineering projects for the transfer of the basics to the practice, three-day group work in the laboratory for the practical experience, own presentation for the analysis and summary of the produced results, writing a detailed report.

Free accommodation in VAO's guest house for the duration of the course!

**Media:**

Lecture (90 min), 2-hour guided tour through the experimental halls in Obernach, 3 days group work on hydraulic model experiments, 1 day presentation and discussion, writing a report.

**Reading List:****Responsible for Module:**

Arnd Hartlieb (arnd.hartlieb@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modelltechnische und flussbauliche Übungen an der Versuchsanstalt Obernach (Übung, 3 SWS)

Hartlieb A [L], Hartlieb A, Scherbaum S, Schlagenhauser M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46034: Hydraulic Machinery and Plants Laboratory | Laborübung Hydraulische Maschinen und Anlagen

*Laboratory Exercises HMA*

Version of module description: Gültig ab summerterm 2016

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>30   | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Brief examination and written elaboration of test results.

The brief examination makes sure students have understood the fundamentals needed to conduct and understand the experiment. In the report, the students describe the experimental setup and the realisation of the experiment. They evaluate the measured data, represent them graphically and discuss their agreement with the theory. In doing so, they show that they are capable of conducting an experiment correctly as well as of representing and interpreting the experimental results.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basic knowledge of hydromechanics

#### Content:

Demonstration of hydraulic machinery and experimental techniques. Small groups of 5 participants perform measurements on pumps, water turbines and plant components and evaluate the results.

The following experiments are conducted:

- Measurement of pressure, pressure losses, flow velocity and discharge in pipes and in open flumes
- Determination of the operational characteristics (performance charts) of a centrifugal pump, a Pelton and a Francis turbine

**Intended Learning Outcomes:**

The students are able to understand the machinery and the flow phenomena connected with hydro power plants.

**Teaching and Learning Methods:**

lecture for imparting the theoretical background,  
discussion and deepening of the topics in the group sessions,  
demonstration and hands-on experiments on hydraulic machinery  
application of the knowledge in writing technical reports

The chosen course form makes sure that students understand the fundamentals required for the understanding of the experiment. While performing the experiments and writing up the reports the students learn to understand the flow phenomena by hands-on experience as well as to conduct an experiment correctly and to present and interpret the results obtained.

**Media:**

printed manuscript, power point presentations in the lectures

**Reading List:**

Reading list given in the manuscript

**Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Laborübung Hydraulische Maschinen und Anlagen (Übung, 2 SWS)

Alapfy B, Scherbaum S, Schlagenhauser M, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46036: Water Resources and Hydropower | Wasserwirtschaft und Wasserkraft [WRHP]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written exam (120 minutes, open book, allowed tools: notes, print medias (books, printed slides...), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

The students will prove that they are able to apply modelling techniques in water management and to design the volumes and water levels of a reservoir.

Furthermore, they prove that they can design a water power station in concept and dimensioning as well as the state-of-the-art technologies for energy storage.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Bachelor's level knowledge in hydraulic engineering, e.g.

- "Basic Module Hydraulic and Water Resources Engineering"
- "Supplementary Module Hydraulic and Water Resources Engineering"

#### Content:

The module provides in-depth knowledge of principles, methods and technologies for calculation and management of water resources, as well as the sustainable generation of energy from hydropower.

- precipitation, runoff and runoff coefficient
- rainfall-runoff modelling

- flood routing
- flood statistics
- reservoir capacity
- storage plans and operation schemes
- flood retention
  
- types of hydro power stations, specific requirements of large and small hydro power
- elements of hydro power installations
- hydro turbines: turbine types, application ranges
- stream turbines: fundamentals, turbine types, application range
- energy conversion in hydro turbines - physical fundamentals
- planning of hydro power stations: hydrological surveys, layout, power plan
- needs and requirements for energy storage
- fundamental options for power storage
- properties of storage technologies, pros and cons, application ranges, potential, development state, project examples
- pumped storage plants: fundamentals, electromechanical equipment, new approaches

#### **Intended Learning Outcomes:**

After successful participation in the module, students will be able

- to apply important and mainly used modelling techniques and calculation methods of water management
- to assess their application areas and limitations
- to design a reservoir under the aspects of hydrology and water resources management
- to describe, identify and assess established and newly proposed technologies of hydropower and energy storage
- to explain and assess the physical foundations of the energy conversion as well as the fundamental approach in planning hydropower projects
- to evaluate hydropower project plans and to perform planning themselves.

#### **Teaching and Learning Methods:**

- lecture style
- practical examples
- coordinated moodle tests (voluntary)

#### **Media:**

- PowerPoint presentations with film sequences and computer animations
- blackboard exercises
- moodle tests (voluntary)
- lecture notes in moodle

#### **Reading List:**

see lecture notes

**Responsible for Module:**

Dr.-Ing. Richard Huber (richard.huber@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Sustainable Water Resources Management (Vorlesung, 2 SWS)

Huber R, Scherbaum S

Hydro Power and Energy Storage (Vorlesung, 2 SWS)

Reisenbüchler M [L], Reisenbüchler M, De Vos L, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU46038: Principles and Applications of Land Management | Prinzipien und Anwendung von Landschaftsmanagement

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment is based on a written exam of 90 minutes with open questions. Such open question test to which extent students can individually formulate feasible and plausible answers in their own words in relation to descriptions, explanations and analysis of basic conceptualisations of land management and landscape management. In addition, the open question should test to which extent students are able to formulate judgements and appropriate solutions for land management challenges and formulate appropriate research questions in relation to land management themes. During the exam only a hardcopy dictionary and a calculator are allowed.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic understanding of of law and environmental systems.

#### Content:

This module will provide foundational knowledge for sustainable land management in both rural and urban areas by a combination of two complementary approaches: land administration and landscape planning.

Land administration comprises of 4 fundamental components: cadastral land surveying, land registration, land valuation and land development. These components together rely on a land information infrastructure and provide the basis for systematic and comprehensive land interventions.

The module will address the guiding principles, formal instruments and procedural elements of Landscape Planning; present methodological approaches for the assessment of natural assets and landscape functions including methods and tools for data collection, analysis and evaluation; illustrate target formulation and implementation strategies with examples from the planning practice.

### **Intended Learning Outcomes:**

On successful completion of the module, participants should:

1. recognize, describe and explain core concepts and principles of responsible and smart land management, land administration and landscape management.
2. explain and apply basic tools, instruments and procedural elements of land administration (including cadastral mapping and land registration) and landscape management.
3. select appropriate methods and tools to design assess natural assets and landscape functions.
4. judge and assess the role and application of land management tools and instruments in the context of sustainable development challenges and requirements.
5. be able to transfer principles and apply tools of land management to secure land tenure, develop and plan urban and rural regions in a responsible and sustainable manner.

### **Teaching and Learning Methods:**

This module relies on active learning methods. The required background knowledge on each of the topics is introduced via both verbal/frontal lectures and via open access background papers and articles (which students have to read and comprehend during and via self study hours). Students are required to apply this knowledge either individually and/or in groups in exercises. The exercises are structured such that students have to combine different sources in order to derive and formulate feasible answers and/or solutions. The exercises are based on actual cases in both Germany and abroad. These seminar type exercises aim to transfer this knowledge for developing a tenure responsive and/or ecologically sustainable strategy at the neighbourhood and/or a national scale. Through these exercises the application of knowledge is practiced. For the exam these knowledge application experiences are required.

### **Media:**

Lectures provide subject specific knowledge; class discussions of selected readings engage students in critical thinking.

### **Reading List:**

Haaren, Chr. v., Galler, C. & S. Ott (2008): Landscape planning. The basis of sustainable landscape development. Ed. by Federal Agency for Nature Conservation; Further thematic reading will be made available in connection with the lectures and the seminar

**Responsible for Module:**

Prof. Walter Timo de Vries wt.de-vries@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Integrated Land and Water Management (Vorlesung, 4 SWS)

de Vries W, Disse M, Pauleit S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46039: Ethics in Science and Technology | Ethik in Wissenschaft und Technologie

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>90    | <b>Contact Hours:</b><br>90                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment is done on the basis of a scientific report.(max. 5 pages)

The students take part actively in the seminar and take part in the discussions. The discussions allow a continuous improvement of the argumentation competence of the students. Through the study of special texts and project examples the knowledge of social challenges of the complex "Nexus - Water-Food-Energy" is improved. Through a presentation (approx. 20 minutes) of a related topic and a written summary with individual argumentation schemes the seminar is completed.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Students must visit first the basic seminar to deepen their knowledge for the advanced seminar.

#### Content:

Scientists and engineers in science and economy at the beginning of their professional career partly face moral challenges which they are hardly prepared for in the traditional study plans. These problems can appear in public discussion or within the realisation of scientific innovations in research and industry. In a basic seminar the models of ethical argumentations are thought. Afterwards the students work on ethical challenges with realistic project examples from the Nexus complex "water-food and energy".

#### Intended Learning Outcomes:

The students develop a better understanding for the nature of the scientific work within the scope of interdisciplinary Nexus - Water, Food and Energy. They get to know the most important ethical

theories and can apply them. The students are enabled to separate technical and normative dimensions of a problem professionally and can develop criteria for a decision. The competence of problem differentiation, reflection, broad argumentation and critical power of judgement is explicitly promoted. The students can judge interdisciplinary projects.

**Teaching and Learning Methods:**

Text reading, talks preparation, problem differentiation, individual and group work, discussion, presentation and written elaboration.

**Media:**

Reader, Powerpoint, Film, Webplattform

**Reading List:**

**Responsible for Module:**

Dr. rer. nat. Eva Sandmann sandmann@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Ethik in Wissenschaft und Technologie - Teil 2 (Vorlesung, 2 SWS)

Sandmann E

Ethik in Wissenschaft und Technologie - Teil 1 (Vorlesung, 2 SWS)

Sandmann E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46040: Ocean and Wind Energy | Meeres- und Windenergie [OWE]

*Potentials, fundamentals and technical possibilities of utilising ocean and wind energy*

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment consists of a written, closed books exam of 90 minutes duration.

The written exam is composed of comprehension and theory questions and comprises all subjects covered in the lecture. It assesses through questions and short tasks if the students are able to rate the potential of the different sources of renewable energy, describe technologies and applications of ocean and wind power plants and understand their economic and ecological implications. Questions targeted at understanding allow students to prove that they understand the link between technologies and the planning and dimensioning of ocean and wind power plants and show they are able to give comprehensive answers to such tasks within a limited time.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge of Fluid Mechanics, e.g. lectures

Fluid Mechanics, Module ID BV410008

Hydromechanics, Module ID BV410013

Fluid and Structural Mechanics, Module ID BV410014

#### Content:

The module consists of a lecture. It is giving an overview on the renewable energy sources wind and ocean energy and the technologies for their utilization in theoretical fundamentals and examples.

For each of the renewable energy carriers wind energy and ocean energy (tidal, ocean current, thermal, osmotic and wave energy) the following aspects are dealt with:

- \* overview over the fundamental utilization possibilities
- \* creation, magnitude and distribution of the potentials
- \* historical development of the technologies for the energetic utilisation
- \* fundamentals of the energy conversion
- \* functional principle, construction and properties of the established as well as suggested technologies and technologies being currently developed
- \* overview over former, recent and suggested projects
- \* construction/deployment and operation
- \* environmental considerations
- \* fundamentals of design and planning

### **Intended Learning Outcomes:**

After a successful participation in the module students are able to:

- know and judge the potentials of the renewable energy sources wind and ocean energy
- understand the processes which create these form of renewable energy
- understand, analyse and evaluate the established and newly suggested technologies for their utilisation
- understand and apply the physical and technical fundamentals applied in the energy transformation
- understand and perform layout and planning of plants for the utilisation of the above mentioned renewable energy sources
- evaluate the ecological impact of the technologies
- estimate potential risks and uncertainties of the technologies
- understand the economic chances and risks of the technologies

### **Teaching and Learning Methods:**

The module consists of a lecture. The theoretical content of the lectures is presented by the lecturer supported by PowerPoint slides and the traditional black board method. Accompanying exercise examples and discussions allow students to participate and to strengthen the interdependencies.

### **Media:**

Power Point presentations with video sequences and animations

### **Reading List:**

Hau, Erich; Wind Turbines: Fundamentals, Technologies, Application, Economics, Springer, Berlin; 2nd rev. ed. (15. November 2005) ISBN-10: 9783540242406, ISBN-13: 978-3540242406

Hau, Erich; Windkraftanlagen: Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Springer, Berlin; Auflage: 4., vollst. neu bearb. Aufl. (Januar 2008) ISBN-10: 3540721509, ISBN-13: 978-3540721505

Kaltschmitt, Martin; Renewable Energy: Technology, Economics and Environment Springer Berlin Heidelberg (9. Dezember 2009), ISBN-10: 3642089941, ISBN-13: 978-3642089947

Kaltschmitt, Martin; Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, Springer, Berlin; Auflage: 4., aktualis., korrig. u. erg. A. (25. August 2009), ISBN-10: 9783540282044, ISBN-13: 978-3540282044

Gasch, Robert: Windkraftanlagen, Teubner B.G. GmbH; 4. Auflage, Dezember 2005, ISBN-10: 3519363348, ISBN-13: 978-3519363347

Gasch, Robert, Jochen Twele: Wind Power Plants, Fundamentals, Design, Construction and Operation. ISBN: 978-3-642-22937-4 (Print) 978-3-642-22938-1

Charlier, R.H. and Finkl, C.W.: Ocean Energy – Tide and Tidal Power; Springer Verlag Berlin / Heidelberg 2009, ISBN 978-3-540-77932-2

Ross, David: Power from the Waves; Oxford University Press, 1995, ISBN 0-19-856511-9

McCormick, Michael E.: Ocean Wave Energy Conversion, Dover Publications Inc., Mineola, New York 2007; ISBN 978-0-486-46245-5

Arthur Pecher, Jens Peter Kofoed, Editors: Handbook of Ocean Wave Energy, Springer Open, Ocean Engineering & Oceanography ISBN 978-3-319-39888-4 ISBN 978-3-319-39889-1 (eBook)

**Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### **BGU46041: Implementation of Water Policy and Water Legislation | Umsetzung von Wasserpolitik und Wassergesetzgebung [GRA\_SEM]**

*Implementation of integrated water resource management in Bavaria and abroad, based on practical examples*

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination consists of an oral lecture (20 ') in the context of the seminar as well as a written elaboration of max. 10 pages. The weight is 50/50.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basic knowledge in water management e.g. by attending the lecture "International Water Policy and Law" in the winter semester

#### **Content:**

The seminar is composed of three pillars:

##### 1. Input from Bavaria

In cooperation with guest lecturers from various Bavarian authorities and associations (e.g. Ministry of the Environment, District Office, Water Management Office, municipal utility associations) current, real case studies from water law and politics in Bavaria are discussed and put into context with past experiences. These case studies should offer a deeper understanding of the content of the lecture in the winter semester and illustrate complex structures and the solution process. As far as possible, content-appropriate excursions can also be offered.

The topics include, for example:

- Good Water Governance principles and indicators and their application

- Processes in the water sector based on selected examples: complex structures, links and weak points
- Water law in practice, e.g. expulsion water protection area
- Interplay of state, parastatal and private actors in the Bavarian water sector
- Implementation of the EU-Water Framework Directive at local level
- Public participation: opportunities and challenges
- Ethical constraints for IWRM in case studies: Responsibility, Assessment, Strategies

## 2. Output international

At the same time, the students carry out their own research and work on a concrete international case study (for example in the SS 17 water sector in Kenya). A comprehensive stocktaking should be used to understand the problem situation and, based on the discussed solutions in Bavaria, develop adapted strategies and propose their practical implementation. The topics are edited and presented in the two-person team and are e.g.

- Basic water management data
- Structures and employees in the water sector
- Water management core tasks: monitoring, hydraulic engineering, protection and use
- Legal situation
- Financing
- Selected processes

## 3. Discussion and abstraction

During the seminar, there is plenty of room for discussion and development of new ideas. These should not only be incorporated into the processing of the international case study. As a result, a general questionnaire for the description and evaluation of water management systems worldwide will be developed during the seminar of lecturers and students.

### **Intended Learning Outcomes:**

After successful completion of the module the students are able

- to understand normative structures in the water sector.
- to assess the concrete challenges in the water sector, especially in an international context.
- analyze water management systems using technical and non-technical indicators.
- apply in-depth knowledge of integrated water resource management in practice.

### **Teaching and Learning Methods:**

Theoretical seminar contents are presented in the form of a lecture by the lecturers, supported by PowerPoint presentations and blackboard work. Accompanying concrete case studies are worked on. A lot of room for discussion enables the students to get involved, to intensify connections and to work out their own solution proposals for their sub-task. During the seminar, the students present their subtasks as part of a lecture.

**Media:**

PowerPoint presentations  
Material and plans of case studies  
Video clips

**Reading List:**

See description of the seminar

**Responsible for Module:**

Patalong, Hannah

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU46042: Modeling of Habitat for Fish and Invertebrates in Rivers | Lebensraummodellierung für Fische und Wirbellose in Flüssen [HABSIM]**

*Modeling of Habitat for Fish and Invertebrates in Rivers*

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

"The performance will be assessed based on a report the students have to deliver. The report shall have a volume of approx. 25 pages and should cover the following topics:

- \* report about the field measurements
- \* report about the data pre-processing
- \* description of the simulation models and methods employed
- \* description of the results obtained
- \* comparison and classification of the results

In this report the students can prove that they have done the practical tasks diligently and they have understood the foundation of the simulation methods. They can show that they have obtained meaningful results and that they can judge their results in the context of other related research.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Bachelor degree in Civil or Environmental Engineering,  
Wasserbau und Wasserwirtschaft Grundmodul, Module No. BV000030,  
Wasserbau und Wasserwirtschaft Ergänzungsmodul Module No. BV000048

#### **Content:**

In the first part of the course, the theoretical background and different aspects of the CFD based fish habitat modelling and the MesoHABSIM technique are presented in the form of lectures.

In the second part, the students work on a case study on a section of the river Obernach with both approaches. This part includes field measurements at the river, data post processing, and the creation and application of models in computer hands-on exercises.

The results of the purely numerical and the physically based approaches are compared and discussed.

### **Intended Learning Outcomes:**

After successful completion, the students will be able to

- \* Understand the fundamentals and procedures of habitat modelling in rivers
- \* Understand the main hydraulic parameters that are decisive for the suitability of the river stretch as a habitat for fish and invertebrae
- \* Acquire data and post-process them for application to numerical models
- \* Perform a CFD-based habitat modelling of a river stretch
- \* Perform a habitat modelling based on the MesoHABSIM technique, a comprehensive planning tool used for the evaluation of environmental flows and of river restoration measures

In summary, students will have a deeper comprehension for the integration of ecological questions in planning processes for civil structures.

### **Teaching and Learning Methods:**

Seminar with integrated practical training, performing computer simulations as well as making practical investigations in the river.

The method applied is complementary Research-Oriented Teaching (ROT) on the above-mentioned field of research. In this course it aims at exposing students to the ecological perspective on the common research area of the TUM, enabling them to combine this view with the theoretical engineering knowledge they are taught in the standard lectures and realize the practical relevance and significance of this knowledge in environmental engineering. The course is giving them the opportunity to learn through conducting their own research and derive their new findings. Free accommodation in VAO's guest house for the duration of the course!

### **Media:**

Powerpoint presentation; computer simulation software

### **Reading List:**

Parasiewicz P. (2001): MesoHABSIM – a concept for application of instream flow models in river restoration planning. Fisheries 29 (9) p. 6–13.

Parasiewicz P. & M. B. Bain (2000): MesoHABSIM or modeling of physical habitat at the scale relevant to river restoration planning. EISORS – Eight International Symposium on Regulated Rivers – Toulouse, France 8/17 – 21 August 2000.

Yi Shen, Panayiotis Diplas (2008): Application of two- and three-dimensional computational fluid dynamics models to complex ecological stream flows. Journal of Hydrology Volume 348, Issues 1–2, 1 January 2008, Pages 195-214

Paul D. Bates Stuart N. Lane Robert I. Ferguson (2005): Computational Fluid Dynamics: Applications in Environmental Hydraulics. John Wiley & Sons

**Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modeling of Habitat for Fish and Invertebrates in Rivers (Seminar, 2 SWS)

Rüther N [L], Reisenbüchler M, Rüther N

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU48029: Introduction to Photogrammetry and Remote Sensing | Einführung in die Photogrammetrie und Fernerkundung [PRG]**

*Photogrammetry and Remote Sensing*

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The written exam takes 60 minutes with content of Photogrammetry and Remote Sensing. Questions contain drawing and explaining figures, answering questions on methods and solutions, calculations or comparisons of methods and their applicability. Additionally, multiple-choice-questions are including with statements that have to be evaluated as true or false. This part does not contain more than 20% of the total points. No aids or materials are allowed.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

None

#### **Content:**

Introduction: Definition Photogrammetry and Remote Sensing

- Characteristics of Photogrammetry, applications and development
- Characteristics of Remote Sensing, applications and development
- Introduction the Photogrammetry: stereoscopic vision and measurement, photogrammetric image analysis, digital stereo processing

- Introduction to Remote Sensing: Radiometric basics, multispectral classification
- Optical basics: models and geometric quality of optical projections, description of image quality

**Intended Learning Outcomes:**

Participants are capable to:

- Analyse applications from different points of view
- Planning aerial image campaigns
- Understand the principles of stereoscopic records
- Evaluate stereo records and produce anaglyphe images
- Understand concepts of photogrammetric image analysis
- Remember the physical basics of the electromagnetic spectrum and radiometric basics
- Understand the principles of supervised and unsupervised classification
- Apply different classifiers and evaluate the classification results
- Evaluate the influence of different factors on the image quality

**Teaching and Learning Methods:**

Lecture: Slides and lecture notes with small examples and discussion

**Media:**

Slides, lecture notes, program examples

**Reading List:**

- "" Haralick, Shapiro (1992): Computer and Robot Vision (Vol. 1). Addison-Wesley, New York.
- "" Castleman (1995): Digital Image Processing. Prentice Hall, Englewood Cliff, New Jersey.

**Responsible for Module:**

Uwe Stilla

**Courses (Type of course, Weekly hours per semester), Instructor:**

PRE - Photogrammetry and Remote Sensing (Vorlesung, 2 SWS)

Hoegner L [L], Stilla U

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### **BGU50007: Ground Water Handling and Sustainable Use of Geomaterials in Civil Construction | Grundwassermanagement und nachhaltige Materialverwendung in der Geotechnik**

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination is a written test of 90 minutes duration. The exam consists of theoretical questions, as well as calculations and design tasks. All study documents, simple scientific calculators and literature are permitted as an aid in the examination.

Through theoretical questions, the students demonstrate that they have understood complex geotechnical groundwater problems and the importance of tailings with regard to geotechnical and environmental challenges as well as different hydraulic failure mechanisms, including the failure of tailings. The calculation and design tasks on the basis of given geotechnical examples are used to verify that the students are able to use calculation approaches for the solution of geotechnical groundwater problems as well as methods for dealing with industrial by-products, RC-materials and other materials in earthworks, taking into account geotechnical and environmental aspects. They also show that they can develop solutions to minimize the impact of construction measures on the groundwater as well as concepts for dealing with difficult soil conditions in earthworks.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Basics in geotechnical engineering and soil mechanics on a bachelor's level

#### **Content:**

- Theory of groundwater flow in porous media and rock
- Hydrogeological site investigation
- Determination of hydraulic permeability of soils (field and lab tests)

- Methods of groundwater lowering (horizontal and vertical gravity wells, vacuum well, electroosmosis, water well design and construction)
- Suffosion, erosion, clogging, hydraulic failure
- Impact of building activities on groundwater level, groundwater bypass
- Effects of groundwater lowering
- Determination of design groundwater level
- Groundwater protection in transport infrastructure
- Geothermal energy (thermal properties of soils, shallow and deep geothermal energy systems)
- Sustainable use of geomaterials: Problem definition, regulations and legal aspects, geotechnical and environmental site investigation, aspects of characterisation of recycled materials and industrial by-products, mechanical and hydraulic properties of recycled materials and industrial by-products, use of slightly contaminated soils and recycled construction materials in earth works, use of problematic soils in earth constructions
- Tailings: general aspects, stability of tailings, environmental aspects and rehabilitation

### **Intended Learning Outcomes:**

After participating in the module the student is able to

- apply a deepened knowledge for geotechnical groundwater problems
- create solutions to minimize the impact of building constructions and activities on groundwater
- create systems for groundwater lowering
- evaluate different types of hydraulic failure of soil structures
- apply a deepened knowledge concerning the handling of mineral waste and recycled construction materials.
- create a modern mass flow management for soil and other earthworks materials considering geotechnical and environmental aspects
- create suitability proof concepts for difficult earthworks materials
- understand the geotechnical and environmental relevance of Tailings
- analyse typical failure mechanisms of Tailings

### **Teaching and Learning Methods:**

The module consists of a lecture.

In the lectures, the theoretical basics, for example groundwater movements, the hydrogeological investigation of building grounds and the measures to influence the groundwater movements, are presented, supported by pictures, films and discussions. Calculation examples from practice-oriented geotechnical engineering tasks provide the quantitative methods for the calculation of relevant groundwater problems in earthworks as well as for the conception of measures for their influence.

All lecture material is provided via the e-learning platform Moodle.

The voluntary weekly colloquium serves as an additional supportive offering for students.

### **Media:**

Lecture notes, overhead-/PowerPoint presentation, blackboard

**Reading List:**

VOGT, N. lecture notes "Studienunterlagen Grundbau und Bodenmechanik"

**Responsible for Module:**

Dr.-Ing. Emanuel Birle e.birle@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Kolloquium zu Grundwassermanagement und nachhaltige Materialverwendung in der Geotechnik  
(Kolloquium, 1 SWS)

Birle E

Grundwassermanagement und nachhaltige Materialverwendung in der Geotechnik (Vorlesung, 4  
SWS)

Birle E, Lypp B, Pena Olarte A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU50008: Geotechnical Issues in Environmental Engineering | Geotechnische Fragestellungen im Umweltingenieurwesen

Version of module description: Gültig ab winterterm 2017/18

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written test of 90 minutes duration. The exam consists of theoretical questions, as well as calculations and design tasks. All study documents, simple scientific calculators and literature are permitted as an aid in the examination.

Theoretical questions on the basis of current environmental geotechnical questions show that the students can understand and present the current legal framework in the field of solid waste disposal, special aspects of the development of opencast landfills as well as relevant technical applications (e.g. suitability of different materials for isolating systems in landfill construction, possibilities for use of recycled materials in environmental geotechnics, methods for the remediation of contaminated sites). Through the calculation and design tasks the students demonstrate that they can apply the basics of water movement in saturated and unsaturated soils for boundary value problems in environmental geotechnical engineering, as well as to design and implement methods for the elimination of old open-castings and methods for soil improvement of open-cast fillings.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Knowledge in geotechnics, environmental geotechnics and soil mechanics on a bachelor's level

#### Content:

- Fundamentals of soil mechanics: Flow of water in saturated and unsaturated soils
- Handling of mineral waste

- Geotechnical design of landfill sites: engineered landfill, base and surface sealing systems, mineral liners, geosynthetic clay liners, geomembranes, transport of contaminants, mechanical properties of waste, stability of landfill bodies, water balance, subsequent use of covered landfills
- Building on fill: mechanical properties of fill materials, ground improvement
- Reutilisation of mineral waste: characterisation of mineral waste and industrial by-products, earth works with mineral waste, technical safeguards for the use of mineral waste in earth constructions
- Remediation of polluted land and abandoned landfills: contaminants, site investigation, remediation by treatment, remediation by containment
- Land reclamation
- Coastal protection

### **Intended Learning Outcomes:**

After participating in the module the students are able to

- to analyse the flow of water in saturated and unsaturated soils
- to evaluate the function of different sealing types for landfills
- to create suitable sealing systems for landfills
- understand the common legal framework for landfill constructions
- apply fundamental knowledge concerning the construction of landfill sites
- evaluate the usage of recycling-construction materials
- evaluate different methods for the remediation of polluted land and abandoned landfills
- evaluate ground improving methods with respect to their applicability for fill material

### **Teaching and Learning Methods:**

The module consists of a lecture.

In the lectures, the theoretical basics, for example the water movement in saturated and unsaturated soils, the landfill sealing systems or the characteristics of different geomaterials, are presented, supported by pictures, films and discussions. Calculation examples from practical environmental geotechnical tasks provide the quantitative methods for the calculation of water movements, for boundary value problems in geotechnics, as well as for the design of measures for landfill isolation and for the remediation of contaminated sites.

All lecture material is provided electronically via the e-learning platform Moodle. In addition, a voluntary colloquium is offered. In the colloquium, students' questions regarding the lecture content are discussed.

### **Media:**

Lecture notes, overhead-/PowerPoint presentation, blackboard

### **Reading List:**

lecture notes "Studienunterlagen Grundbau und Bodenmechanik"

GDA-Empfehlungen Geotechnik der Deponien und Altlasten, DGGT <http://www.gdaonline.de/empfehlung.html>

Verordnung über Deponien und Langzeitlager vom 27.04.2009

FGSV: Merkblatt über Bauweisen für Technische Sicherungsmaßnahmen beim Einsatz von Böden und Baustoffen mit umweltrelevanten Inhaltsstoffen im Erdbau (MTSE), Ausgabe 2008

LAGA: Anforderungen an die stoffliche Verwertung von mineralischen Abfällen - Technische Regeln - Allgemeiner Teil, 2003

LfU-Deponie-Info - Merkblatt 1: Mineralische Deponieabdichtungen, 2009

FGSV: Richtlinien für bautechnische Maßnahmen an Straßen in Wasserschutzgebieten (RiStWag), 2002

**Responsible for Module:**

Dr.-Ing. Emanuel Birle [e.birle@bv.tum.de](mailto:e.birle@bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Kolloquium zu Geotechnische Fragestellungen im Umweltingenieurwesen (Kolloquium, 1 SWS)  
Birle E

Geotechnische Fragestellungen im Umweltingenieurwesen (Vorlesung, 4 SWS)

Birle E, Cudmani R, Vogt S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU52015: Visualization of Spatial Data in Transportation | Visualisierung von Raum- und Verkehrsdaten

Version of module description: Gültig ab winterterm 2015/16

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of submission of two homework tasks which are group works (weighting 30% of the overall grade) and the design of a final individual poster (70% of the overall grade) with a short presentation (not graded). Homework are to assess that the students are able to structure data, demonstrate conceptual and concrete plans and produce understandable posters as a group. First homework concentrates on creating conceptual and large scale maps while second one focuses on small scale, detailed maps. With the final poster each student demonstrate that s/he can create a comprehensive poster with many data on different scales in a clear, attractive and meaningful way and represent her/his ideas precisely. It is also checked if each student can use the basic functions of a Design-Software. For the final poster, it is important that students prepare it by combining the graphs, maps and tables that were produced during the homework with improvements after feedbacks and critics. Students present their posters with short verbal presentations. The assessment method is decided as project work composed of poster submission.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

GIS, Interactions of Land-Use and Transport (ILUT)

#### Content:

1. Introduction and overview of methods of presentation
2. Presentation of visions, project ideas and planning concepts.
3. Presentation of concrete plans: level of detail, requirements and methods for different scale transport and land use plans

4. Introduction to the illustration and design tool CorelDRAW Graphics Suite.(Students that can use and prefer other tools are allowed to use them for further group work)
5. Visualization Exercises with ArcGIS
6. Homework Presentation 1 and discussion
7. Homework Presentation 2 and discussion
8. Final Presentation

### **Intended Learning Outcomes:**

After participating the module, students are expected to be able:

- to clearly demonstrate conceptual and concrete planning ideas on a problem or on an existing plan.
- to use some Graphic-Design/Visualization Programs in order to development and urban transport plans as well as additional visuals (Tables, charts, text...etc.).
- to structure big/complex data or maps.
- to evaluate quality of maps, presentations and/or posters from others concerning the representativeness of the ideas and comprehensiveness of the figures.
- to produce understandable, attractive and correct transport and urban planning maps/plans.
- to design understandable and comprehensive Tables and Charts in order to illustrate complex situations

### **Teaching and Learning Methods:**

The Module consists of lectures, tutorials and exercises. The lectures are on basic design and visualization concepts so that the students can learn how to successfully demonstrate conceptual and concrete planning ideas and be able to evaluate the design differences between good and bad examples. Tutorials are executed in order to show the students how to use a graphic software in planning. Exercises are composed of three homework pieces on different visualization types (conceptual and two different scales) so that students can learn how to organize/structure provided big/complex data, produce new maps/graphics and practice the software. Homework pieces, which are created as group work, will be collected during the semester, will be presented and discussed in the class together. At the end of the semester students will design their own individual poster with those maps and graphics in line with feedbacks that they got during the semester.

### **Media:**

Lecture Presentations, Design and Mapping Tools, Maps, Projects and Presentations of Students

### **Reading List:**

Yau, Nathan (2011) Visualize This: The Flowing Data Guide To Design, Visualization and Statistics.

Ware, Colin (2013) Information Visualization: Perception for Design.

### **Responsible for Module:**

Wulforth, Gebhard; Prof. Dr.-Ing.



**Courses (Type of course, Weekly hours per semester), Instructor:**

Visualization of Spatial Data in Transportation (Vorlesung, 2 SWS)

Büttner B [L], Büttner B ( Rivas De Gante A, Nichols A )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU52016: Evaluation of Transport Projects and Policies | Evaluation von Verkehrsprojekten und -programmen

Version of module description: Gültig ab winterterm 2013/14

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

During the semester, students will be asked to submit a piece of homework (group work) which contributes to 20% of the overall grade. A final written exam will count 80% of the required achievements. Questions in the written exam will be based on the lecture and central pieces of literature, as indicated during the lecture.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Interactions of Land-Use and Transport (ILUT)

#### Content:

1. Rationale of public decision-making
  - a. Difference between public and private investment decisions
  - b. Welfare economics basis of investment
2. External costs and accounting prices in transport
  - a. Valuing time costs in transport
  - b. Valuing transports contribution to climate change
  - c. Valuing local emissions
  - d. Valuing transport safety risks
3. Impact evaluation and evidence-based policies
4. Beyond the independent planner: policy process and evaluation
  - a. Do we need an ethics of planning?

- b. Public choice critique of welfare economics
- c. Transaction costs of politics and transport policy
- d. Interest groups and public investment decisions
- e. Bureaucracy and public decision making

**Intended Learning Outcomes:**

After participating the module, students are expected to be able to:

- understand the normative basis of ex ante evaluation for public decision making,
- assess how to relate policy objectives to planning tools,
- assess the potential of ex post evaluations for decision making,
- explore the main interactions between policy processes and public decision making.

**Teaching and Learning Methods:**

The Module consists of lectures, and video conferenced tutorials. In addition, students are expected to submit a written exposée on one of the topics of the lecture. There will be 2 lecture days. At the end of semester, a final written exam is required.

**Media:**

Lecture Presentations, photocopied relevant literature

**Reading List:**

**Responsible for Module:**

Wulfhorst, Gebhard; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54008T2: Hydrological and Environmental River Basin Modelling | Hydrologische und ökologische Flussgebietsmodellierung [HERBM]

Version of module description: Gültig ab winterterm 2013/14

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a 90 minute written exam and additional course work.

In the written exam, the students show that they have achieved the learning outcomes under pressure of time (knowing and understanding constituents of transport processes /cycles of matter and their numerical modelling). The exam consists of 1/3 theoretical questions and 2/3 calculations. Allowed tool is a non-programmable calculator.

The course work serves to assess the students' competence to apply an eco-hydrologic model and to process the simulation output data. Further the ability to analyze and present the results in a comprehensive way is tested.

During the exercises the students start the course work (e.g. model setup, methods to evaluate modelling results) and receive support by student tutors and the lecturing tutor. After they have received the final question for the course work, the students can continue working on it during the remaining exercises and during self-study hours in groups of 4 persons and have to prepare and hand in a written report (approx. 20 pages).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basics of hydrology and GIS

#### Content:

Different components of an eco-hydrological model and their interactions will be explained and their respective calculation methods will be presented:

- Climate data and snow
- Evapotranspiration
- Infiltration and soil water

- Surface runoff
- Groundwater
- Streamflow

Additionally, modelling of plant growth and associated water as well as nutrient demands are presented. Water quality aspects and the interplay with issues of land use and management practices are also brought up.

- Nutrients and nutrient transport
- Erosion
- Plant growth and management practices

Eco-hydrological modelling will be taught based on a practical example in the computer lab:

- Model setup in SWAT
- Carrying out simulations
- Evaluation of model results: data post-processing
- Evaluation of model results: interpretation of results and diagnosis
- Manual calibration

### **Intended Learning Outcomes:**

At the end of the module, the students are able to:

- understand how environmental processes (i.e. concerning the water cycle) are modelled in numerical eco-hydrological software model like SWAT.
- understand different methods for the calculation of single components of eco-hydrological cycles and their interplay.
- use an eco-hydrological model
- process the model results for evaluation
- identify different influencing factors on the model quality
- assess the meaningfulness of model results and
- present them in a comprehensive fashion in a final assessment report.

### **Teaching and Learning Methods:**

The module consists of a lecture and an exercise.

Lecture (talk, presentation, group work): The lecture provides the historical, mathematical and empirical basics for various modelling approaches to the different model components (e.g.: Green and Ampt in comparison with SCS-CN method to model infiltration). The underlying assumptions, characteristics (Which kind of behavior, observed in nature do we want to mimic? For instance the seasonal and sinusoidal oscillation of soil temperature and damping with depth), data requirements and limits of application are discussed. The lecture therefore aims at the first two study goals.

Exercises (talk, presentation, individual and group work, case study): A detailed investigation of single model components as it is done in the lecture is hardly possible for the practical application of the software. The interplay of model components (climate, soil, aquifers, runoff, sediments, plant growth) is often complex and non-linear over time. The application of a software model, the understanding of the interplay of its many components as well as the assessment of the results is taught and learned with hands-on exercises – computer lab and course work.

**Media:**

Lecture; PowerPoint presentations, black board, scientific papers,

Exercise: Script, Software: SWAT, ArcSWAT, SWATPlot, Excel, R, SWATCup, Technical Manuals

**Reading List:**

Neitsch, S., J. Arnold, J. Kiniry, and J. Williams (2011). Soil and water assessment tool- theoretical documentation version 2009. Report, Grassland, Soil and Water Research Laboratory - Agricultural Research Service, Blackland Research Center - Texas AgriLife Research.

Winchell, M., R. Srinivasan, M. diLuzio, and J. Arnold (2007). ArcSWAT Interface for SWAT2005 - Users Guide. [http://www.geology.wmich.edu/sultan/5350/Labs/ArcSWAT\\_](http://www.geology.wmich.edu/sultan/5350/Labs/ArcSWAT_Documentation.pdf)

Documentation.pdf: Blackland Research Center and Grassland, Soil and Water Research Laboratory (USDA Agricultural Research Service)

Arnold, J., J. Kiniry, R. Srinivasan, J. Williams, E. Haney, and S. Neitsch (2011). Soil and Water Assessment Tool- Input/Output File Documentation Version 2009. <http://swat.tamu.edu/media/19754/swat-io-2009.pdf>: Grassland, Soil and Water Research Laboratory Agricultural Research Service, Blackland Research Center Texas AgriLife Research.

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse ([markus.disse@tum.de](mailto:markus.disse@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrological and Environmental River Basin Modelling (Vorlesung, 2 SWS)

Disse M, Tuo Y

Hydrological and Environmental River Basin Modelling - Exercise (Übung, 2 SWS)

Disse M, Tuo Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54009: Flood Risk and Flood Management | Hochwasserrisiko und Hochwassermanagement [FRM]

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a 120-minute written test. Only permitted aid is non-programmable calculator. The necessary mathematical formulas are given on the test sheets.

In the written exam, the students demonstrate that they can explain the concepts of hydrological floodwater modeling and flood risk management, taking into account the legal framework as well as social boundary conditions. Through practical tasks on typical flood events, they demonstrate that they can apply quantitative methods for damage and risk assessment, as well as perform risk-based assessment and sensitivity analysis of the effectiveness of flood protection measures.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamentals of hydrology (e.g. Hydrology Basic Module (BGU54006), bachelor program Umweltingenieurwesen, TUM),

Fundamentals of probability theory and risk analysis (e.g. Environmental Monitoring and Risk Management (BGU54007 or BGU54025), bachelor program Umweltingenieurwesen, TUM),  
Fundamentals of programming in Matlab

#### Content:

First the general motivation of flood risk management (FRM), the social and political framework of FRM as well as tools and models for the hydrologic/hydraulic modelling of the flood events are provided. Also different strategies and measures of technical and decentral flood protection are included. In the second part of the course, quantitative methods for analyzing the flood damage and flood risk and for risk-based evaluation/optimization of the flood protection measures. The accompanying exercises will provide brief summary of programming in MATLAB and the students

will learn how to implement the theory explained in the lectures on simple but realistic examples using Matlab and the water balance model LARSIM, which is used wide spread in Middle Europe for flood forecasts.

#### Lecture

- Safety, security, and risk
- The risk management cycle
- Qualitative and quantitative methods for flood risk assessment
- Planning of flood protection measures: determination of design values
- Flood frequency statistic base on gauged data
- Contents and significance of the EU directive on the assessment and management of flood risks
- Overview of technical and decentral flood protection measures
- Failure of flood protection measures
- Flood hazard scenarios
- Risk and risk acceptance: Communication of risks and legal aspects.

#### Exercise

- LARSIM: Understanding and dealing with the water balance model LARSIM in reasons of flood forecast and river basin modelling.

#### Quantitative risk assessment: lecture and exercise

- Decision-making, risk acceptance, optimization of mitigation measures
- Flood damage assessment
- Risk quantification
- Uncertainty quantification, sensitivity analysis
- Issues of long-term planning: non-stationarity, adaptability

#### **Intended Learning Outcomes:**

After completing the module, the students are able to:

- Understand the basic concepts of flood risk management as well as its legal and social framework,
- to apply methods for the hydrological modeling of flood events;
- to apply quantitative methods for general risk assessment and damage assessment as well as for specific flood risks
- evaluate and select the effectiveness of flood protection measures.
- to apply sensitivity analysis
- to use the MATLAB programming in the specific field of flood risk management.
- to use the hydrological water balance model LARSIM to solve questions of flood prediction.
- to structure and implement the theoretical and mathematical concepts in calculation algorithms.

#### **Teaching and Learning Methods:**

The module consists of lectures with integrated exercises.

The theoretical basics are presented through a lecture series. The students are encouraged to study the recommended literature and deepen their knowledge in certain topics. Computer



exercises based on practical problems are solved by the students. They sharpen their technical skills in dealing with MATLAB and LARSIM. The exercises are individual or group work. Voluntary homework tasks, which are to be worked in groups,

**Media:**

Power-Point-Presentation,  
Blackboard,  
Computer lab

**Reading List:**

The documents and resources listed below are some examples for your interest:

Flood Manager E-Learning (TU Hamburg-Harburg): <http://daad.wb.tu-harburg.de/homepage/>

Merz, B., J. Hall, M. Disse, and A. Schumann. "Fluvial Flood Risk Management in a Changing World." *Natural Hazards and Earth System Science* 10, no. 3 (March 16, 2010): 509–527. doi:10.5194/nhess-10-509-2010.

Rogger, M., Kohl, B., Pirkl, H., Viglione, A., Komma, J., Kimbauer, R., Merz, R., Blöschl, G., 2012. Runoff models and flood frequency statistics for design flood estimation in Austria – Do they tell a consistent story? *J. Hydrol.* 456–457, 30–43.^

Bründl, M., Romang, H.E., Bischof, N., Rheinberger, C.M., 2009. The risk concept and its application in natural hazard risk management in Switzerland. *Nat. Hazards Earth Syst. Sci.* 9, 801–813.

Pianosi, F., Wagener, T., Rougier, J., Freer, J., Hall, J., 2014. Sensitivity Analysis of Environmental Models: A Systematic Review with Practical Workflow, in: *Vulnerability, Uncertainty, and Risk*. American Society of Civil Engineers, pp. 290–299.

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse ([markus.disse@tum.de](mailto:markus.disse@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Flood Risk and Flood Management (Vorlesung mit integrierten Übungen, 4 SWS)

Disse M [L], Broich K, Disse M ( Broich K, Gerner A ), Gerner A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54010: Groundwater Hydraulics, Modelling and Management | Grundwasser - Hydraulik, Modellierung und Management [GHMM]

Version of module description: Gültig ab winterterm 2013/14

|                                |                                    |                                   |                                      |
|--------------------------------|------------------------------------|-----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>120   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam consists of two written parts (each of 60 min.) and each part of the exam needs to be passed to pass the module as a whole. The first part will focus on the course groundwater hydraulics, the second one on the course groundwater modeling and management. This will allow verifying the understanding by the students of each course. The exam will verify i) how the students understand basic concepts of flow and transport processes in porous media; ii) how the students are able to apply those concepts for the solution of problems within a given period of time. The exam will consist of open questions, multiple choice questions and mainly exercises which will require short computations. No auxiliary material is allowed during the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in hydrology, environmental monitoring and fluid mechanics (e.g. the BSc courses Grundmodul Hydrologie, Umweltmonitoring und Risikomanagement, Fluid Mechanics)

#### Content:

- Groundwater hydraulics (Basic equations)
- models to describe the motion within the porous medium (Darcy's Law, potential flows)
- continuity for confined and unconfined aquifers
- differential equations describing subsurface flows and their solutions (drainage, wells)
- Conceptualization of groundwater modelling
- Finite difference numerical solution for solving steady and transient flow (PMWIN, Modflow and MATLAB)
- Spatial variability of parameters
- Flow modelling (Modflow)

- Calibration for parameter estimation of observed field data (PMWIN, Modflow, PEST/UCODE, SmartGEO)
- Solute transport modelling (PMWIN, Modflow, MOC3D/MT3D/MT3DMS)
- 3D groundwater flow and transport modelling (PMWIN, Modflow, MT3DMS)

### **Intended Learning Outcomes:**

At the end of the module, students are able:

- to understand the basic processes controlling subsurface flow and the different scales in ground water hydraulics
- to apply their governing equations as well as to apply groundwater hydraulics equations (analytic equations and partial differential equations) for flow in porous media.
- to predict subsurface flow for wells in confined / unconfined aquifers.

Upon completion of the modelling and management part the students will be able

- to evaluate different groundwater management strategies
- to create flow and transport modeling based on field measurements
- to apply them to determine the flow field and well protection zone
- to understand aquifer parameters and
- evaluate the expansion of pollutant plumes.

Through a series of computer exercises, the students will be familiar with the following tools: PMWIN, MT3D, and MATLAB.

### **Teaching and Learning Methods:**

Lectures (Power-Point-Presentation, blackboard), exercises (individual, small groups), homework (modelling exercise).

The teaching philosophy behind this module is based on the evidence that different study goals will be achieved using different approaches. While theoretical concepts and mathematical equations require an in-depth explanation, which is provided during the lectures, the understanding of a model requires hands-on learning, which will be provided during exercises and homework. During the lectures, the student will understand the theory, which is behind the model they are going to use in the exercises and homework. In this way, at the end of the module, they will be able to create their own model for the solution of flow and transport in porous media.

### **Media:**

Power-Point-Presentation  
Blackboard  
Script

### **Reading List:**

- Chiang, W.-H., & Kinzelbach, W. (2001). 3D-Groundwater Modeling with PMWIN (With CD-ROM). Springer. Retrieved from <http://www.amazon.com/3D-Groundwater-Modeling-PMWIN-With-CD-ROM/dp/3540677445>
- G. de Marsily, Quantitative Hydrogeology, Academic Press, 1986

- Holzbecher, E. (2012). Environmental Modeling: Using MATLAB. Springer.
  - J. Bear, Hydraulics of Groundwater, McGraw-Hill, New York, 1979
  - P.A. Domenico, F.W. Schwartz, Physical and Chemical Hydrogeology, J. Wilson & Sons, New York, 1990
- "PEST- Model interdependent parameter estimation users manual. Watermark computing. Australia
- Poeter, E. P. and M. C. Hill, 1998. Documentation of UCODE, a computer code for universal inverse modeling, U.S. Geological Survey, Water-Resources Investigation Report 98-4080
  - Skriptum Grundwasserhydraulik
  - Vogelgesang, Grundwasser, Springer-Verlag, 1998

**Responsible for Module:**

Dr. Gabriele Chiogna (gabriele.chiogna@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Grundwasserhydraulik (Vorlesung, 2 SWS)

Manhart M, Unglehart L

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54011: Integrated Water Resources Management | Integriertes Wasserressourcen Management [IWRM]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a written, closed book test of 120 min duration. The exam will consist of open questions, multiple choice questions and mainly exercises which will require short computations.

Through short and precise answers to theoretical questions, the students demonstrate that they are able to understand the principles of integrated and sustainable water management; different institutional roles in the water management sector in several countries, methods and tools of integrated water resources planning and management as well as analyze and evaluate water related decision problems. The practical part is based on exercises mainly associated to the analysis and application of a preliminary IWRM plan, to the application of simulation tools for a river basin, and to the application of the most common optimization methods in water resources management problems. This will allow verifying the understanding by the students concerning the application of basic IWRM concepts, their ability to differentiate between a range of river basin management tools and models as well as apply those concepts (e.g. linear and nonlinear optimization tools) for the solution of problems within a given period of time.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge of hydology

#### Content:

1. Introduction
  - Introducing Water Resources Management
  - The Overall Problem and Main Challenges

- Need for optimized water resources management
- System Components, Planning Scales and Sustainability
- Planning and Management
- Integrated Water Resources Management
- Definition of IWRM
- IWRM History and Principles
- The enabling environment
- The institutional roles
- Management instruments
- Water Management at River Basin Scale
- IWRM and capacity development
- 2. Decision Support Systems (Short Introduction)
- 3. Water Resources Planning and Management River Basin Management Overview
  - Framework for water resources planning and management
  - Modelling of Water Resources Systems
  - River Basin Planning and Management Models
  - Modelling Methods: Simulation, Optimization, Multi Criteria Analysis
- 4. Optimisation
  - Short Introduction to Economics for Engineers
  - Introduction to optimization
  - Calculusbased methods
  - Linear optimization
  - Dynamic optimization
  - Multiobjective optimization
- 5. Multi Criteria Analysis
- 6. Uncertainty Analysis
  - Time Series Generation
  - Sequent peak algorithm and Reservoir Management

#### **Intended Learning Outcomes:**

At the end of the module, students are able to:

- understand the principles of integrated and sustainable water management,
- understand different institutional roles in several countries,
- apply linear and nonlinear optimization tools,
- analyze and evaluate water related decision problems,
- differentiate between a range of river basin management tools and models.
- understand and apply methods and software tools of integrated water resources planning and management .

#### **Teaching and Learning Methods:**

The module consists in a lecture with integrated exercises.

The teaching concept of this module is based on the fact that different study goals will be achieved using different approaches. While theoretical concepts and mathematical equations require an indepth explanation, which is provided during the lectures, the understanding of a model

requires hands-on, practical learning, which will be provided during the integrated exercises and the homework. During the lectures, the students will understand the theory behind the models. They are going to apply those models in the integrated exercises and the homework. Whenever necessary, a complementary theoretical background of the models is provided in the exercises in order to enhance the understanding of the students. In this way, at the end of the module, they will be able to create their own model from one side, of a river basin and to make an analysis of various water allocation and water resources management strategies and from the other side, to build an optimization problem and to solve it for the most important water resources problems (optimal water allocation, storage capacity – yield, reservoirs operation and groundwater supply).

Students have to bring their own laptop to the computer exercises.

**Media:**

Power-Point-Presentation, blackboard, software

**Reading List:**

- Water Resources System Planning and Management (Daniel P. Loucks)
- Global Water Partnership Technical Advisory Committee (TAC) Background paper on Integrated Water Resources Management
- <http://www.gwp.org/en/The-Challenge/What-is-IWRM/Dublin-Rio-Principles/>
- Bonn 2011 Conference proceedings The Water, Energy and Food Security Nexus, Solutions for the Green Economy
- United Nations World Water Assessment Programme

**Responsible for Module:**

Prof. Dr.-Ing Markus Disse [markus.disse@tum.de](mailto:markus.disse@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Integrated Water Resources Management (Vorlesung mit integrierten Übungen, 4 SWS)

Disse M [L], Chiogna G, Disse M, Gerner A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54013T2: Seminar in Rainfall-Runoff Modelling | Seminar Niederschlags-Abfluss Modellierung [SRRM]

Version of module description: Gültig ab winterterm 2014/15

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Total duration: 45 min.

- Presentation and discussion (30 min.)
- Oral exam (15 min.)

#### Repeat Examination:

#### (Recommended) Prerequisites:

Hydrological fundamentals,  
e.g. Grundmodul Hydrologie (Bachelor Umweltingenieurwesen, TUM)

#### Content:

The course contents are based on the book Rainfall-Runoff Modelling: "The Primer" by Keith Beven from Lancaster University:

The book provides a primer for the novice and detailed descriptions of techniques for more advanced practitioners. [&] It gives a comprehensive summary of available techniques based on established practices and recent research, [offering] a thorough and accessible overview of the area.

- 1.Runoff Processes and the Modelling Process
- 2.Evolution of Rainfall-Runoff Models
- 3.Data for Rainfall-Runoff Modelling
- 4.Predicting Hydrographs Using Models Based on Data



5. Predicting Hydrographs Using Distributed Models Based on Process Descriptions
  6. Hydrological Similarity, Distribution Functions and Semi-Distributed Rainfall Runoff Models
  7. Parameter Estimation and Predictive Uncertainty
  8. Models for Changing Risk
  9. Next Generation Hydrological Models
  10. Predictions in Ungauged Basins
  11. Water Sources and Residence Times in Catchments
  12. Hypotheses, Measurements and Models of Everywhere
- 

### **Intended Learning Outcomes:**

At the end of the module, students are able to:

- Know the theory of different types of rainfall-runoff models.
- Understand the concepts that underlie different modelling approaches.
- Evaluate models and critically assess the assumptions made.

Furthermore the students should learn to:

- Present a topic, as well as to facilitate and lead a discussion about it.
- 

### **Teaching and Learning Methods:**

The module consists of a seminar with an introductory lesson given by the lecturer. The students will form groups of two people and pick a topic they will present in the consecutive lessons. The activities comprise:

- Literature study
  - Summarizing and presenting a topic
  - Guiding and facilitating a discussion on the presented topic
  - Consecutive online tests
- 

### **Media:**

Powerpoint  
Blackboard

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### **Reading List:**

Beven, K. J. Rainfall-Runoff Modelling: The Primer. 2nd ed. Chichester, West Sussex/; Hoboken, NJ: Wiley-Blackwell, 2012.

AVAILABLE as .pdf download though the TUM library (eaccess login -> search in UB catalogue)

**Responsible for Module:**

Markus Disse (markus.disse@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Seminar in Rainfall-Runoff Modelling (Vorlesung, 2 SWS)

Disse M [L], Tuo Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU54015: Water Management at the Catchment Scale (Field trip to the Adige River Basin) | Wassermanagement auf Einzugsgebietsebene (Exkursion in das Etsch Einzugsgebiet) [WMCS]**

Version of module description: Gültig ab summerterm 2016

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>50   | <b>Contact Hours:</b><br>40          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The students, divided into small groups (max 3 persons), will prepare a short report (15-20 pages) about one of the 4 topics related to the field trip: management of hydropower production in Alpine catchments, climate change and the Alpine cryosphere, contaminant loads in rivers, salt water intrusion. Each group will prepare a presentation of the report (20 minutes) during the field trip at the location where that particular issue is relevant. The evaluation of the exam will be based on

- a) the capability of the students to work autonomously during the literature review related to their research topic (group grade 40 %)

- b) the quality of the written report and of the oral presentation (group grade 40%)

- c) oral exam following the oral presentation (single grade 20%) about a specific aspect of the presentation

Beside the technical skills it will be evaluated the quality, the accurateness and the style of the presentation of the results and the team-working capacity.

In this way, it will be possible to evaluate both the performance of the group and the performance of each single component as well. The relative weight of the grade depends on the required workload.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

- Hydrological and Environmental River Basin Modelling
- Integrated Water Resources Management
- Modeling and Management of Groundwater

**Content:**

The field trip will be performed in collaboration with the University of Trento, Department of Civil, Environmental and Mechanical Engineering (Prof. Bellin) and within the FP7 EU Project Globaqua ([www.globaqua-project.eu](http://www.globaqua-project.eu))

The course will focus on the following topics:

- Management of hydropower production in Alpine catchments
- Climate change and the Alpine cryosphere
- Contaminant loads in rivers
- Salt water intrusion

**Intended Learning Outcomes:**

At the end of the module students are able:

- to understand that water management is an issue to be faced at the catchment scale
- to evaluate the effects of climatic forcing on the alpine cryosphere and their effect on water management
- to evaluate the water quality of water bodies at different scales
- to analyze the effects of saltwater intrusion in the Mediterranean region
- to analyze their results in order to prepare an effective oral and written presentation

**Teaching and Learning Methods:**

The course will be offered as a field trip of 5 days. In this way, the student will understand through a direct experience the main issues related to water management at the basin scale. Furthermore, in order to prepare their report and the oral presentation, the students will understand the relevance of team-working. It will required an extensive literature review of the assigned topic, which will be synthetized with a discussion between the group members.

**Media:**

Introduction in the different issues related to water management at the catchment scale and supervision of the groups

**Reading List:**

- Scientific articles of peer review journals depending on the seminar topic
- The EU water framework directive - integrated river basin management for europe ([http://ec.europa.eu/environment/water/water-framework/index\\_en.html](http://ec.europa.eu/environment/water/water-framework/index_en.html))

**Responsible for Module:**

Dr. Gabriele Chiogna ([gabriele.chiogna@tum.de](mailto:gabriele.chiogna@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Water Management at the Catchment Scale (Field trip to the Adige River Basin) (Seminar, 2 SWS)  
Chiogna G [L], Chiogna G, Disse M

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](#).

## Module Description

### **BGU54016: Process Based Modelling of Mesoscale Pre-alpine Catchments | Prozessbasierte Modellierung mesoskaliger voralpiner Einzugsgebiete [MPAC]**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The exam consists of a project work to be presented both in written and oral form. The written report (30-40 pages long) is a group work on the theoretical background and the application of the two presented models including preprocessing, model generation and results. The results have to be presented to the class in an oral presentation (20 minutes presentation followed by a discussion). The written report and the oral presentation are equally weighted.

Auxiliary means are not allowed.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Basic knowledge in hydrology and hydraulics

#### **Content:**

- 1) Dominant hydrological processes in pre-alpine catchments: Precipitation types and snow processes; runoff generation, concentration and flood routing
- 2) Data in small alpine catchments: availability, quality, acquisition and analysis
- 3) Types of hydrological and hydraulic models and applicability in pre-alpine catchments
- 4) Generation, parameterization and calibration of the process based hydrological model WaSiM
- 5) Model sensitivity analyses with focus on interpolation of the meteorological input, snow processes and runoff concentration
- 6) Process based modeling of the flood routing processes using the 2D-hydrodynamic-numerical model HYDRO\_AS-2D
- 7) Analysis of the water balance influenced by different land use and climatic boundaries

8) Quantification of the effectiveness of flood mitigation measures using the (coupled) modeling approach

**Intended Learning Outcomes:**

At the end of the module, students are able to understand the main processes in pre-alpine catchments like snow processes as well as runoff generation, runoff concentration and flood routing processes. Additionally, they are able to understand different methods for the calculation of these processes. Moreover, students are able to use a physically based hydrological model and a 2d hydrodynamic-numerical model to simulate the rainfall runoff process in pre-alpine catchments and its influencing parameters caused by the special circumstances of these regions in a widely realistic and transparent way. The students are able to generate event based scenarios as well as land use scenarios and based on this to evaluate different flood mitigation strategies for such regions.

**Teaching and Learning Methods:**

Lectures, block seminar and exercises

**Media:**

- PowerPoint presentations
- Technical manuals

**Reading List:**

DeWalle, D.R. & Rango, A. (2008): Principles of snow hydrology. Cambridge University Press, Cambridge and UK and New York.

Hydrotec Ingenieurgesellschaft mbH & M. Nujić (2014): Benutzerhandbuch HYDRO\_AS-2D - 2D-Strömungsmodell für die wasserwirtschaftliche Praxis. Aachen, November 2014

Schmocker-Fackel, P., Naef, F. & Scherrer, S. (2007). Identifying runoff processes on the plot and catchment scale, Hydrol. Earth Syst. Sci., 11, 891 - 906. [www.hydrol-earth-syst-sci.net/11/891/2007/](http://www.hydrol-earth-syst-sci.net/11/891/2007/).

Schulla, J. (2014): Model Description WaSiM: Water balance Simulation Model. Zürich.

Warscher, M., Strasser, U., Kraller, G., Marke, T., Franz, H. & Kunstmann, H. (2013): Performance of complex snow cover descriptions in a distributed hydrological model system: A case study for the high Alpine terrain of the Berchtesgaden Alps. In: Water resources research 49 (5), pp. 2619-2637.

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse

**Courses (Type of course, Weekly hours per semester), Instructor:**

Process based modelling of mesoscale pre-alpine catchments (Vorlesung, 4 SWS)

Disse M [L], Broich K, Disse M, Merk F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU54019: Numerical Modeling of Water Demand and Supply in Arid Regions | Numerische Modellierung von Wasserbedarf und -Versorgung in ariden Gebieten [OWHM]**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The exam consists of the development of a project (i.e. a numerical model with the software OWHM) to be presented in oral form (20 minutes presentation followed by a discussion). The exam will verify i) how the students understand basic concepts of water demand and supply in arid regions; ii) how the students are able to apply those concepts for the solution of realistic case studies.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Basic Module Hydrology (BSc)

Groundwater modeling (MSc)

#### **Content:**

- Basics of water management in arid regions
- Introduction to MODFLOW-OWHM (One Water Hydrologic Model)
- Specific packages of OWHM and physical description of the processes
- Development of the case study
- Presenting a case study

#### **Intended Learning Outcomes:**

At the end of the module, students are able:

- i) to understand the basic principles behind water management in arid regions.
- ii) to apply a physically based model to manage water resources in arid regions.
- iii) to predict water availability according to specific water management conditions.



The course will provide to the students both the theoretical as well the practical knowledge to use MODFLOW-OWHM to solve water management issues in arid regions, including irrigation. Upon completion of the modelling and management part the students will be able to evaluate different groundwater management strategies, to create flow and transport modeling based on field measurements and to apply them to determine water availability, to understand aquifer parameters and evaluate the sustainability of water management options.

**Teaching and Learning Methods:**

Lectures (Power-Point-Presentation, blackboard), exercises (individual, small groups), homework (modelling exercise).

The teaching philosophy behind this module is based on the evidence that different study goals will be achieved using different approaches. While theoretical concepts and mathematical equations require an in-depth explanation, which is provided during the lectures, the understanding of a model requires hands-on learning, which will be provided during exercises and homework. During the lectures, the student will understand the theory, which is behind the model they are going to use in the exercises and homework. In this way, at the end of the module, they will be able to create their own model for the solution of flow and transport in porous media.

**Media:**

Power-Point-Presentation

Blackboard

**Reading List:**

- Chiang, W.-H., & Kinzelbach, W. (2001). 3D-Groundwater Modeling with PMWIN (With CD-ROM). Springer.

- One water hydrologic flow model: <https://pubs.er.usgs.gov/publication/tm6A51>

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse ([markus.disse@tum.de](mailto:markus.disse@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Numerical modeling of water demand and supply in arid regions (OWHM) (Vorlesung, 2 SWS)

Disse M [L], Disse M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54021: Remote Sensing in Hydrology | Fernerkundung in der Hydrologie [RSH]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination is done via a 90 minute written exam. The exam consists of 2/3 theoretical questions and 1/3 calculations. Allowed tool is a non-programmable calculator. Based on theoretical questions, the students show that they understand the principles of remote sensing in hydrology and can evaluate the different satellite products in terms of quality and can understand how to integrate remote sensing data in hydrological modelling to solve the practical limitations of point-based ground measurements. Based on short calculations the students demonstrate that they understand various mathematical procedures for estimating key hydrological components by the means of remote sensing data.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basics of hydrology, hydrological modelling and GIS

Basics of GIS software ArcGIS or QGIS

Basics of programming in Matlab and/or Python

Ability to literature review and critical thinking of scientific journal papers

#### Content:

Contents for lectures:

In first two theoretical lectures, the fundamentals of hydrology and remote sensing will be explained.

Then in the following theoretical lectures, remote sensing methods for different hydrological components and the applications in case studies will be explained and presented:

- Precipitation
- Vegetation

- Evaporation
- Soil moisture
- Water level and water volume
- Groundwater
- Snow and ice

The application of remote sensing in other environmental studies such as land use and land cover classification, soil erosion and water quality will also be briefly discussed.

#### Contents for exercises in the computer lab

The methods for processing various remote sensing products in different formats will be taught based on a practical example in the computer lab:

- Visualization of satellite data (Landsat, MODIS, Sentinel etc.) and projection in ArcGIS
- Processing satellite precipitation TRMM data and comparison with measurements from WMO stations
- Processing vegetation index products from different satellites
- Processing satellite ET products and surface temperature products
- Processing satellite soil moisture products
- Analysis of satellite altimetry data for water level in lakes and reservoirs
- Analysis of groundwater variation from GRACE satellites
- Analysis of MODIS satellite snow cover products

#### **Intended Learning Outcomes:**

1. At the end of the module, the students are able to understand the principles of remote sensing, and how the satellite products for various hydrological components are generated.
2. Students will be able to process various satellite products in the different data formats using ArcGIS, QGIS and some programming software Matlab and Python.
3. Students will be able to evaluate the satellite products, to identify different influencing factors on the satellite data quality, and how to and how to integrate satellite products to hydrological modelling to solve practical problems.

#### **Teaching and Learning Methods:**

The module consists of a lecture.

Lecture (talk, presentation, group work): The lecture provides the fundamentals of hydrology and remote sensing, mathematical remote sensing calculation methods and data formats for various hydrological components (e.g. precipitation, evaporation, water level), and applications of remote sensing in practical hydrological studies.

Exercises (talk, presentation, individual and group work, case study): Hands-on exercises will be given in the computer lab. A detailed investigation of single hydrological components as it is done in the lecture will be achieved through the practical processing of the satellite products. The application of software and programming and the data evaluation will be taught in more details. During the exercises the students learn the satellite data processing in a more practical hands-on manner. The students are expected to learn how to download and process the satellite data. The processing procedures in ArcGIS and some programming in Matlab and Python will also be taught during the exercises. Students will receive support by student tutors and the lecturing tutor. During

the exercise, some small exercises will be assigned but they will be voluntary and used only for students' self-assessment. In the end, a voluntary report can be also handed in: students can form a group with 2 or maximum 4 members to select a topic (e.g. precipitation, water level) to write a report with an approx. 20 pages.

The lectures and exercises in computer lab will be closely linked to achieve the study goals.

**Media:**

Lecture; PowerPoint presentations, black board, scientific papers,

Exercise: Script, Software: ArcGIS, QGIS, Excel, Matlab, Python, and Technical Manuals.

**Reading List:**

Schultz, G. A., & Engman, E. T. (Eds.). (2000). Remote sensing in hydrology and water management. Springer Science & Business Media.

Campbell, J. B. (2002). Introduction to remote sensing. CRC Press.

Davie, T. (2008). Fundamentals of hydrology. Taylor & Francis.

Gebremichael, M., & Hossain, F. (2010). Satellite rainfall applications for surface hydrology. New York: Springer.

Papers from the following journals: Remote Sensing of Environment, Water Resources Research, Journal of Hydrology, International Journal of Remote Sensing etc.

User manuals for specific satellite products. The manuals will be specified during lectures.

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse (markus.disse@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Remote Sensing in Hydrology (Vorlesung, 4 SWS)

Disse M [L], Tuo Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54024: Uncertainty Quantification in Hydrology | Unsicherheitbestimmung in der Hydrologie [UQH]

*Uncertainty quantification in hydrology*

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The students prepare a comprehensive presentation of 60 minutes about a seminal paper related to uncertainty quantification in hydrology. The evaluation considers the quality of the presentation (clarity of the oral presentation and slides), its structure (comprehensiveness beyond the literature provided by the lecturer), capability of answering questions and clarifying both mathematical and hydrological concepts.

The oral presentation of a hydrological paper demonstrates the understanding of the student about the relevant issue of uncertainty quantification in hydrological parameter estimation and predictions. Moreover, it verifies how well the students can summarize complex mathematical and hydrological concepts and explain them to other students within a given period of time. Through short and precise answers to theoretical oral questions, the students demonstrate that they are able to understand the principles and the methods used for uncertainty quantification in hydrology.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Advanced hydrological knowledge
- Advanced statistical knowledge
- Familiarity with preparation of slides and oral presentations

#### Content:

Each student will receive one scientific publication related to uncertainty quantification in hydrology to be presented during the seminar. The assigned publications could be changed every year according to the most recent and valuable scientific publications. The publications will be chosen among open access journals or journals freely accessible to students from the library.

Topics that will be discussed are:

- Model uncertainty in hydrology
- Parameter uncertainty in hydrology
- Parameter estimation
- Model inversion
- Bayesian inversion
- Latin hypercube method
- Markov Chain Monte Carlo Simulations
- Monte Carlo Simulations
- Estimation of effective model parameters
- Equifinality in hydrological models

### **Intended Learning Outcomes:**

The students at the end of the module will be able to:

- Understand and analyse the theory, the methods and the results presented in a scientific paper focusing on uncertainty quantification in hydrology
- Understand and analyse the methods inherent to uncertainty quantification in hydrology
- Evaluate autonomously the relevant literature necessary for the understating of the assigned paper in the field of uncertainty quantification in hydrology
- Create a presentation to explain an assigned topic in the field of uncertainty quantification in hydrology

### **Teaching and Learning Methods:**

The 13 students participating to the seminar will be guided by the lecturer in the oral presentation of a scientific paper. The presentations must be prepared in electronic form by the students following the instructions provided by the lecturer. This teaching method will allow the students to achieve the four learning outcomes described above.

An open discussion involving also the other participants will be moderated by the lecturer after each presentation. This teaching method will allow the students to achieve the first three learning outcomes described above. It is required that each student will participate to the discussion taking place after each student's seminar.

### **Media:**

Powerpoint-Präsentation, Tafelanschrieb, digitale Vorlagen

### **Reading List:**

The assigned publications could be changed every year according to the most recent and valuable scientific publications.

Example of papers that could be used in the seminar are:

Mattis, S. A., Butler, T. D., Dawson, C. N., Estep, D., & Vesselinov, V. V. (2015). Parameter estimation and prediction for groundwater contamination based on measure theory. *Water Resources Research*, 51(9), 7608-7629.

Kitanidis, P. K. (1986). Parameter uncertainty in estimation of spatial functions: Bayesian analysis. *Water resources research*, 22(4), 499-507.

Vrugt, J. A., Ter Braak, C. J., Clark, M. P., Hyman, J. M., & Robinson, B. A. (2008). Treatment of input uncertainty in hydrologic modeling: Doing hydrology backward with Markov chain Monte Carlo simulation. *Water Resources Research*, 44(12).

**Responsible for Module:**

Gabriele Chiogna

**Courses (Type of course, Weekly hours per semester), Instructor:**

Uncertainty quantification in hydrology (Seminar, 2 SWS)

Chiogna G [L], Chiogna G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54026: Urban Flood Modelling | Modellierung städtischer Überschwemmungen [UFM]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

At the end of the module, students submit a report (10-15 pages) with corresponding presentation (circa 15 min). The report is a written record and summary of the three main exercises followed during the Module, covering the setup, application and analysis of the results from three different urban flood models (sewer network model, overland flow model and dual drainage flow model). The report will verify that the students understood the basic concepts of flood modelling in urban areas and that they were able to apply those concepts for the solution of problems within a given period of time. The students will work in groups of maximum of three. The presentation is also done in groups. The presentation will verify if the students are able to present their results in a coherent manner, discuss and answer questions related to urban flood modelling.

Prüfungsart

Report (10-15 pages)

Prüfungsdauer (in Minuten)

15 min presentation +10 min discussion

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Fundamentals of Hydrology (e.g. Hydrologie Grundmodul)
- Basic Knowledge of Sewer Drainage Systems (e.g. Siedlungswasserwirtschaft Grundmodul - Kanalisation)
- Basic Knowledge of Arc-Map

#### Content:

Introduction: Overview of the most important urban hydrological and hydraulic processes and concepts.



Challenges in urban flood modelling, in relation to flood management and flood risk assessment.

T1. Sewer drainage model I - SWMM model setup of Maxvorstadt (computational work).

T2. Sewer drainage model II - analysis of results (computational work).

Introduction to overland flood models in urban areas.

T3. Overland flow model I – P-DWave model setup of Maxvorstadt (computational work).

T4. Overland flow model II – analysis of results (computational work).

Introduction to dual drainage models.

T5. Dual drainage flow model I - P-DWave/SWMM setup of Maxvorstadt (computational work).

T6. Dual drainage flow model II - analysis of results (computational work).

Urban flood management: Sustainable Urban Drainage System (in Munich).

Discussion/Feedback on the report.

Presentation and discussion of the report.

Wrap-up.

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### **Intended Learning Outcomes:**

The students at the end of the module will be able to understand and analyse:

- the fundamental concepts of urban flood modelling,
- the need and usefulness of different model types
- the different types of Sustainable Urban Drainage Systems (SUDS)

Finally, the students are able to discuss the range of applicability as well as advantages and disadvantages of different UFM for different contexts, namely, flood risk and flood management, and for different densifications of urban areas

### **Teaching and Learning Methods:**

Lecture with integrated computational exercises. 3 computer exercises (each split in two parts).

The exercises can be done in group. Students submit a report (10–15 pages) summarizing their results. Students will receive feedback during the lectures on their reports. Students will prepare and present their reports during the lecture period

### **Media:**

Powerpoint, black-board, PDFs, teamwork followed by discussion

### **Reading List:**

### **Responsible for Module:**

Jorge Leandro, [jorge.leandro@tum.de](mailto:jorge.leandro@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Urban Flood Modelling (Vorlesung mit integrierten Übungen, 2 SWS)

Teixeira Leandro J [L], Teixeira Leandro J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU56033: Freight Transport Concepts / Logistics | Güterverkehrskonzepte / Logistik

Version of module description: Gültig ab winterterm 2013/14

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of this course is conducted in written form. This is to verify that students are able to understand problems in the field of the course contents without using any aid (exception: non-programmable calculator) and within a limited amount of time. They shall demonstrate their capabilities in finding ways to solve these problems. The written exam covers the entire lecture material. Students are required to answer both multiple-choice questions and questions with freely formulated answers. In addition, short calculation tasks have to be accomplished.

#### Repeat Examination:

#### (Recommended) Prerequisites:

-

#### Content:

1. Introduction "Freight transport - demand and provided services" (Transportwirtschaft Nachfrage & Angebot)
2. The Value Chain (Nachfrageseite)
  - 2.1. Supply Chain Management - Production Perspective (Produktionssicht)  
Supply Concepts (JIS/JIT/to stock),  
Bullwhip-Effect  
CPFR Collaborative Planning and Forecasting  
SCM Process Modelling with SCOR
  - 2.2. Trade Supply Structures Trade perspective (Handelssicht)
  - 2.3. The Last Mile - Customer perspective (Endverbrauchersicht)  
The impact of time windows, VRP-TW
3. Transportation Networks (Angebotsseite)

- 3.1. Transport Objects (Güter und Ladungsträger)
- 3.2. Network Nodes (Wertschöpfung an Netzknoten)  
Storage, Picking, Transshipment (Technical Concepts)
- 3.3. Network Links (Transportleitung auf Netzkanten)  
Transport Modes (Rail, Road, Air, Rivers, Deep Sea, Pipelines)
- 3.4. Network Structure Planning (Netzstrukturplanung)  
Planning Tasks, Net-Topologies, cml-FLP
- 4. Vertical Industry Examples (Branchenbeispiele)  
Agriculture, Food&Beverage, Oil&Gas, CEP ...

### **Intended Learning Outcomes:**

After completion of the module, the students are able to:

- Understand concepts of freight transport in terms of structures, demand and supply
- Know and understand principles of organisation and planning of freight transport
- Model selected tasks as tour planning and location management for freight transport
- Solve tasks by using algorithms

### **Teaching and Learning Methods:**

Lecture; autodidactic literature research

The lecture provides a quick introduction into the world of Operations Research and normalises the previous knowledge of students. To understand the topics covered an additional and detailed study of specified literature is necessary. Therefore, selected topics from those independent literature studies will be discussed in the lecture. Small exercises enable the students to work independently upon practical tasks.

### **Media:**

slide presentations only; own notes to be taken by students;

### **Reading List:**

[Brandimarte, Zotteri 2007] Introduction to Distribution Logistics; [Klaus, Feige 2008] Modellbasierte Entscheidungsunterstützung in der Logistik; [Arnold, Furmans 2005] Materialfluss in Logistiksystemen

### **Responsible for Module:**

Bogenberger, Klaus; Prof. Dr.-Ing.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Univ.-Prof. Dr.-Ing. Fritz Busch (fritz.busch@tum.de)

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU56048: Traffic Data Collection and Analysis | Verkehrsdaten - Erfassung und Analyse [TD-C&A]

Version of module description: Gültig ab summerterm 2017

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The evaluation includes a written examination of 60 minutes, in which the student should demonstrate an ability to independently identify the problem in a given amount of time and reach a solution without the use of aid materials. The test consists of factual and understanding questions as well as calculatory questions that are oriented towards the exercises. All questions must be completed without the use of aid materials. The exam checks, if the student remembers and understands the different types of traffic sensors (local, stationary route based, on-board) as well as environmental sensors. In addition, proposals for systems have to be analysed, evaluated and, if necessary, alternatives have to be developed. In case of complex calculatory questions, a formula sheet containing the necessary formulas discussed in the lecture and tutorial will be provided for the exam.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Profound knowledge of intelligent transport systems and traffic flow theory as being presented in the following TUM-modules:

- Traffic Engineering and Transport Planning Basic Module (BV560029)
- Traffic Engineering and Transport Planning Supplementary Module (BV000047)
- Modeling and Control of Traffic Flow (BGU56045)

#### Content:

The lecture consists of a theoretical background and its practical application in the field of acquisition and processing of traffic data.

The contents of teaching consist of:

- Local and spatial traffic data acquisition
- Environmental data acquisition
- Floating Car Data
- Routing and map matching
- Methods for traffic data analysis
- Implementation of field tests (e.g. using automated number plate recognition)

**Intended Learning Outcomes:**

After participating in the module, the students are able to:

Develop, conduct and analyze field tests for the acquisition of traffic and environmental data and to use modern traffic detection systems.

**Teaching and Learning Methods:**

The module consists of lectures and a seminar with project work. The contents of the lectures are given in an oral presentation using power point slides. The seminar teaches methods and introduces measurement equipment that will be used in a field test resulting in a project work.

**Media:**

PowerPoint, study trips, demonstrating and applying detection equipment.

**Reading List:**

ASt (2002): Technische Lieferbedingungen für Streckenstationen (TLS). Bundesanstalt für Straßenwesen (HRSG), Köln, 2002.

FGSV (2001): Handbuch für die Bemessung von Straßenverkehrsanlagen (HBS).

Forschungsgesellschaft für Straßen- und Verkehrswesen e.V., Köln, 2001

**Responsible for Module:**

Dr.-Ing. Spangler, Matthias

**Courses (Type of course, Weekly hours per semester), Instructor:**

Verkehrsdaten - Erfassung und Analyse (Seminar, 3 SWS)

Bogenberger K [L], Dumler K ( Dandl F, Spangler M ), Glöckl U ( Dandl F, Spangler M ), Spangler M ( Dandl F, Dumler K )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU60015: Reliability for Engineering Systems | Zuverlässigkeit von Systemen

*Reliability of engineering systems*

Version of module description: Gültig ab summerterm 2016

|                       |                             |                                  |                                      |
|-----------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b>  | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3 | <b>Total Hours:</b><br>120  | <b>Self-study Hours:</b><br>80   | <b>Contact Hours:</b><br>40          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In the oral examination the student should be able to reflect and reproduce the contents of the course. The student will be given one problem that is oriented at the lectures as well as the homework and exercises throughout the semester. The student should study the problem and outline a solution during 15 minutes. Subsequently he/she will present his/her solution and answer follow-up questions. The students have to be able to describe and reflect important theories. Solutions will be discussed and examined during iterative rounds of questions. The oral examination enables the examiners to be responsive to the individual student and to evaluate the student's competences realistically.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Risk Analysis 1

#### Content:

1. General introduction and brief review of course prerequisites
2. Binary system models
3. Fault tree and event tree analysis
4. Dependent failures
5. Physically-based system models
6. Sampling-based system reliability
7. Performance and sensitivity measures

**Intended Learning Outcomes:**

This course enables the student to analyze, manage and communicate the reliability of infrastructure, technical and environmental systems. Upon completion of the course, students will be able to:

- Select appropriate system models for reliability assessment.
- Utilize traditional tools for system reliability and risk analysis, such as fault and event trees.
- Model complex engineering systems through sampling based methods.
- Compute system failure probabilities
- Model and assess the effect of dependence among system components
- Identify important components and failure modes in systems.
- Implement the methods in computational tools such as Matlab

**Teaching and Learning Methods:**

The course will consist of lectures, including application examples, and exercises from the fields of civil, environmental, structural and transportation engineering.

Lectures will be given on the blackboard and through slides. Case studies should help the understanding of the problems. The lecture notes in PDF form will be distributed at the beginning of the semester.

Homework will be provided but is not compulsory.

**Media:**

- Lectures with blackboard supported by slides
- Supervised study
- Lecture notes including theory and examples
- Optional homework examples

**Reading List:**

Bedford, T., and Cooke, R. (2001). Probabilistic risk analysis: foundations and methods, Cambridge University Press.

**Responsible for Module:**

Prof. Daniel Straub [straub@tum.de](mailto:straub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Zuverlässigkeit von Systemen (Vorlesung, 2 SWS)

Straub D, Teichgräber P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU60021: Risk Assessment and Reliability of Engineering Systems | Risikobewertung und Systemzuverlässigkeit [RA&SR]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

There will be a oral exam of 40 minutes duration at the end of the semester. It will be an open book exam, thus notes and aids are allowed. The student should study the problem and outline a solution during the first 20 minutes. In the subsequent 20 minutes he/she will present his/her solution and answer follow-up questions. Solutions will be discussed and examined during iterative rounds of questions. The oral examination enables the examiners to be responsive to the individual student and to evaluate the student's competences realistically.

The problems to be solved in the exam are based on the lecture contents and the exercises of the semester. The students need to be able 1) to explain main concepts in their own words and 2) to solve arithmetical problems. The students are supposed to show if and up to what extent they have understood the principles and concepts of the theory of probability and if they are able to apply these concepts to problems in the field of engineering.

The student can submit an assignment during the semester. Successful completion gives a bonus of 0.3 for the final grade.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Risk Analysis

#### Content:

Part Risk Assessment:

1. General introduction
2. Bayesian networks



3. Utility theory
4. Decision analysis
5. Life-cycle analysis and cost-benefit analysis
6. Risk acceptance
7. Risk management

**Part System Reliability:**

1. General introduction
2. Time-dependent reliability
3. Binary system models
4. Fault tree and event tree analysis
5. Dependent failures
6. Physically-based system models
7. Sampling-based system reliability
8. Performance and sensitivity measures

**Intended Learning Outcomes:**

This course enables the student to analyze, manage and communicate the reliability of and risks in civil systems and environment. Upon completion of the module, students will be able to:

- Understand reliability, risk, utility, and, decisions.
- Understand traditional tools for system reliability and risk analysis, such as fault, event and decision trees.
- Select appropriate system models for reliability assessment.
- Model complex engineering systems and decisions under uncertainty
- Identify important components and failure modes in systems.
- Assess risk acceptance criteria.
- Plan risk management for engineering systems.
- Model complex engineering systems through sampling and simulation based methods.
- Implement the methods in computational tools such as Matlab

**Teaching and Learning Methods:**

The course consists of lectures, including application examples, and exercises from the fields of civil, environmental, structural, mechanical and transportation engineering.

Lectures will be given on the black/whiteboard, including selected illustrations. Case studies should help the understanding of the problems. The lecture notes in PDF form will be distributed at the beginning of the semester.

Homework, accompanying the lectures, will be provided.

**Media:**

- Lectures with blackboard supported by slides
- Lecture notes including theory and examples
- Optional homework examples

**Reading List:**

Lecture notes and selected papers will be distributed.

**Responsible for Module:**

Herr Prof. Dr. sc. Tech. Daniel Straub [straub@tum.de](mailto:straub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Risikobewertung (Vorlesung, 3 SWS)

Straub D, Teichgräber P

Zuverlässigkeit von Systemen (Vorlesung, 2 SWS)

Straub D, Teichgräber P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU62039: Case Studies of Sustainable Urban Developments and Infrastructure | Fallstudien nachhaltiger Quartiers-, Stadt- und Infrastrukturentwicklungen [FNQSI]**

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The examination performance is achieved by writing a scientific paper in the form of an essay (about 5-7 pages). This is worked on in groups of 2-3 students. At the end of the semester, the results are presented in a graded short lecture and finally discussed.

The aim is to demonstrate that the students have understood and can critically reflect on the essential aspects of how sustainable neighborhood, urban and infrastructure development was implemented in the case study and that they can present their findings in an appropriate form.

The overall grade of the module is composed of the essay (70%) and the short presentation (30%). The examination is done online: the essay is uploaded on Moodle and the presentations take place via ZOOM.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

The contents of the modules

BV620007 Fundamentals of sustainable construction

BV000029 Traffic engineering and traffic planning basic module

BV000031 Urban water and waste management basic module

should be familiar to the students

**Content:**

In this module, the connections between urban planning and engineering as well as architectural concepts and the energy, material and traffic flows associated with them are shown and, above all, their implementation is dealt with in more detail.

Individual projects in the field of building construction and civil engineering as well as infrastructure systems and settlement quarters are examined and analyzed in more detail. The implementation of these projects, taking into account the location, social and societal aspects, as well as the integration of energy and political issues, are examined in a practical manner using case studies. The new building as well as projects of the reorganization, projects in the range plus energy house, zero-emission quarters are consulted.

Here, the criteria of sustainability are exemplarily dealt with in the phases of planning, construction, operation and deconstruction, in order to be able to evaluate buildings, structures, systems and developments in an active discussion in the future.

**Intended Learning Outcomes:**

After attending the module, students will be able to:

- apply the criteria for sustainability on the basis of exemplary projects and understand their influence on and interactions with the parameters involved.
- understand sustainable developments in cities and neighborhoods as well as civil engineering and building construction from spatial, structural, material, cultural and social aspects.
- evaluate the different subsystems such as infrastructure, building stock, new construction, urban planning framework, energy supply, traffic, mobility, water, waste, food, education, social structure, resources/ cycles at neighborhood level, microclimate, quality of life, social structures, use structures, economic structures.
- Understand concepts of active and passive building technology as well as intelligent building envelopes and building control systems.
- to understand factors such as comfort, climate, energy consumption, finiteness of resources and CO<sub>2</sub> emissions and their mutual influence.
- understand scenic analyses and examples and apply them to other properties with their own proposed solutions.

**Teaching and Learning Methods:**

The module consists of a lecture series and a seminar.

In addition to the lecturers, external experts from science and practice are involved in the lecture series. The various actors in urban development provide the students with practical insights into the different subsystems of the city and are available for discussions.

In the seminar, the content taught in the lecture is further deepened through interactive formats such as workshops, discussions, student presentations and group mentoring, as well as a multi-day field trip to the current case study.

Participants\* in the module each choose a topic/object from the course content at the beginning of the semester. The possible focal points are related to the case study of the current semester. These are assigned to one of the overarching themes of the city, such as material flows, mobility, neighborhoods, or buildings.

During the semester, the chosen topic/object is intensively studied by the students, visited on site if necessary, and presented. The development takes place in small groups of 2-3 students each. In addition, individual contents and methods are further deepened in accompanying workshops. The intermediate presentations, in the course of the development of the essay, serve as practice.

The students actively participate in the excursion components and develop their own concepts and strategies.

Towards the end of the semester, the result is submitted as a written paper (essay of 5-7 pages plus graphics, images, appendices, etc.).

It is then presented in the form of a short lecture and discussed together. As a rule, the students present the work of another group.

#### **Media:**

Slides, lecture notes (to be developed from each semester's lecture focus), posters, presentations. Field trips and site visits to the properties discussed in the case studies with supporting guest lectures and on-site tours.

#### **Reading List:**

Friedman, T. L. (2009). Hot, flat, and crowded: Why we need a green revolution--and how it can renew America

(Release 2.0, updated and expanded ; 1st Picador ed.). New York: Picador/Farrar, Straus and Giroux.

Heck, H.-D., & Meadows, D. L. (1972). Dennis Meadows [u.a.] Die Grenzen des Wachstums (The limits to growth, dt.).

McDonough, W., & Braungart, M. (2002). Cradle to cradle: Remaking the way we make things (First edition). New York: North Point Press.

#### **Responsible for Module:**

Prof. Dr.-Ing. Werner Lang sekretariat.enpb.bgu@tum.de

#### **Courses (Type of course, Weekly hours per semester), Instructor:**

Fallstudien nachhaltiger Quartiers-, Stadt- und Infrastrukturentwicklungen (Seminar, 2 SWS)

Lang W [L], Hernández Chamorro A, Lang W, Schwering K, Theilig K

Nachhaltige Quartiers-, Stadt- und Infrastrukturentwicklungen (Vorlesung, 2 SWS)

Lang W [L], Hernández Chamorro A, Schwering K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU62041: Sustainable Architecture, Urban and Landscape Planning - for Environmental Engineering | Nachhaltige Architektur, Stadt- und Landschaftsplanung - für Umweltingenieurwesen**

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Type of examination: scientific paper

The form of examination is a scientific paper consisting of two parts. Part A is individual work (30%) and part B (70%) is group work. The total volume is about 12-14 pages per person and should be uploaded via Moodle.

#### **Part A**

Analytical summary of the contents of the various lectures against the background of the sustainable city, taking into account the ecological, socio-cultural and economic aspects in relation to the challenge of building with a positive ecological footprint.

Students should be able to reflect the general sustainability criteria (such as settlement density, settlement structure) in their entirety and be able to explain urban planning aspects (such as separation of functions and mixing of functions with regard to the quality and quantity of traffic movements) and the use of greenery in the city.

#### **Part B**

Working on a topic of specialisation in which the essential approaches of sustainable architecture urban and landscape planning in the fields of materials, building concepts, energy supply and integration of renewable energies as well as in urban development, spatial planning and in accessibility and mobility are presented, analysed, interpreted and applied in summary form. The topics will be assigned at the beginning of the semester.

#### **Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

Successful participation in module BV620007 - Basics of sustainable building is recommended

**Content:**

The module consists of a lecture series and a seminar that focuses on the contents of the lectures. The module presents the main approaches to sustainable architecture, urban and landscape planning and analyses and evaluates the interfaces and interactions between the subject areas within the overall system.

In the course of the lecture, technical experts convey the basics of planning in the areas of landscape architecture/public space, interactions between spatial and transport planning, sustainable urban development, accessibility as a basis for designing sustainable mobility, electromobility, regenerative energy systems/energy management, building physics/energy-efficient construction, energy use, resource-saving construction, building materials and materials, construction technology and life cycle engineering, comfort and load management, real estate development and valuation, and digital tools for early design planning.

In the seminar, the individual topics are taken up and examined in depth. Connections between urban planning, architectural and technical concepts are taught and the associated energy, material and traffic flows are shown. Starting from the cultural-historical classification and the historical development of sustainability, approaches to solutions for the consideration of engineering aspects with regard to sustainable planning and action are examined and developed. This is done by means of examples on a topic-related basis, in part also independently. An overview of the systemic interaction of the individual planning components is developed, on the basis of which the effects of decisions of the individual planning participants on the overall planning system are clarified

**Intended Learning Outcomes:**

After attending the module, students are able to

- to understand general sustainability criteria in architecture, urban and landscape planning in existing and new buildings and groups of buildings and the associated systems in the fields of materials, building concepts, energy supply and integration of renewable energies as well as in urban development, spatial planning and in accessibility and mobility
- to understand the interrelationships of the consumption of resources (energy, material, water)
- to analyse questions of energy and resource use in the building sector with regard to the potential of sustainable planning
- to evaluate the interrelationships and the systemic interaction of the individual planning components to achieve sustainable planning approaches
- to independently analyse current political and regulatory frameworks and the issues they contain on the basis of the characterised systemic effects
- evaluate the effects of planning decisions on the overall system
- to independently and critically examine current issues and to develop appropriate strategies and solutions.
- to reflect learned complexes of topics in a condensed form and to give presentations



### **Teaching and Learning Methods:**

The teaching content of the lecture is conveyed through lectures by subject experts. In order to deepen the content of the lectures, the students provide a short written summary of the essential statements of the experts and place the lecture in the context of the sustainable city. Based on this and on supplementary lectures, discussions are held on issues of sustainable planning in the various fields in order to analyse the teaching material and develop possible solutions. Furthermore, supplementary contents and calculation methods will be developed and presented in group work. In group work, the teaching content can be discussed already during the summary, so that a deeper examination of the topic is achieved. The presentation in front of the entire seminar group enhances the students' skills of condensed reproduction as well as their presentation skills.

### **Media:**

Folien, Beamerpräsentation, Literatur, Computerberechnungen

### **Reading List:**

Bott, H., Grassl, G.C., & Anders, S. (2014). Nachhaltige Stadtplanung: Konzepte für nachhaltige Quartiere. [München]: Detail.

Ekardt, F. (2016). Theorie der Nachhaltigkeit: Ethische, rechtliche, politische und transformative Zugänge - am Beispiel von Klimawandel, Ressourcenknappheit und Welthandel (2., vollständig überarbeitete und aktualisierte Auflage). Baden-Baden: Nomos.

Friedman, T. L. (2009). Hot, flat, and crowded: Why we need a green revolution--and how it can renew America (Release 2.0, updated and expanded ; 1st Picador ed.). New York: Picador/Farrar, Straus and Giroux.

Heck, H.-D., & Meadows, D. L. (1972). Dennis Meadows [u.a.] Die Grenzen des Wachstums (The limits to growth, dt.).

McDonough, W., & Braungart, M. (2002). Cradle to cradle: Remaking the way we make things (First edition). New York: North Point Press.

Meadows, D. H., Meadows, D. L., & Randers, J. (1992). [Hauptband] (6. Aufl.). Die neuen Grenzen des Wachstums : die Lage der Menschheit: Bedrohung und Zukunftschancen / Donella H. Meadows: A. Stuttgart: Dt. Verl.-Anst.

### **Responsible for Module:**

Prof. Dr.-Ing. Werner Lang

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Nachhaltige Gebäudeplanung im urbanen Kontext (Seminar, 2 SWS)  
Lang W [L], Hernández Chamorro A, Lang W, Schwering K

Nachhaltige Architektur, Stadt- und Landschaftsplanung - Vorlesung (Vorlesung, 2 SWS)  
Lang W [L], Hernández Chamorro A, Lang W, Schwering K, Staudt J  
For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU62043: Aspects of Sustainable Urbanism | Aspects of Sustainable Urbanism

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

written/drawn, cumulative exercises: The Module consists of two parts (A+B) and will be credited with 6 ECTS when both parts are passed successfully.

Part A (40%, individual work): Lecture series and accompanying workshop. Completion of one assignment, that will be developed (from various disciplinary perspectives of sustainable urban design) during workshop sessions and presented in the final session. The assignment will require students to investigate and discuss the presented topics within the particular context of a city. Attendance at the lecture and workshop sessions is mandatory.

Part B (60%, group work): Individual reflection of lecture content, workshop results and reading in a short text and graphic summary as a poster and presentation.

Part A and B are Uploads on Moodle.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

No previous knowledge in the field is required.

#### Content:

The module provides systemic insight into basic principles of Urban Planning and Design, Urban (Re-)Development, based on key principles Sustainable Urbanism. Focal aspects are (amongst others): – the perception and exploration of key challenges of transformation, techniques of problem identification and conceptualization of resolution strategies in the urban realm, – application of exemplary morphologic and physiologic indicators of urban structure, as well as – the illustration of urban regenerations processes in best practise urban projects. The module confronts the student with a repertoire of possibilities to integrate complex spatial, aesthetic, social, cultural, ecological and sustainable qualities into contemporary living environments. Physical

encounters with the city (on-site workshops) are featured for studying important urban settings and city phenomena in real life.

**Intended Learning Outcomes:**

After attending the lecture and completing the exercises, the students are able to recognize and understand current patterns of transformation of contemporary urban and suburban structures including connections between ecological, societal and economic factors. Based on the presentation of examples, students can reflect and understand basic ideas and approaches towards more sustainable living environments. Workshop sessions provide insight into the application of basic instruments of urban design and sustainable urban development and enable students to make connections with the focus of their major field of study and its toolsets.

**Teaching and Learning Methods:**

Lecture series that feeds into a practice seminar: Basic urban design topics are introduced by lecture to then be individually applied in the workshop researching actual plots.

**Media:**

keynote, exercise sheets, sketching paper

**Reading List:**

Jane Jacobs. The death and life of great American cities. 1961.

Jan Gehl. Cities for people. 2010.

David Grahame Shayne. Recombinant Urbanism. 2005.

**Responsible for Module:**

Werner Lang sekretariat.enpb.bgu@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Sociocultural Perspectives of Sustainable Cities (Aspects of Sustainable Urbanism) (Vorlesung, 2 SWS)

Lang W [L], Schade C, Schwering K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU62052: Renewable Energy Supply in Buildings | Erneuerbare Energieversorgung von Gebäuden

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module exam is a written exam ( 90 minutes) in which students have to evaluate and apply various theories and findings relating to regenerative energy supply to buildings. The students have to answer some of the questions in their own words and make various calculations on their own.

The examination takes place online as an openbook exam via Moodle.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

no basic knowledge is needed

#### Content:

Students learn about the correlations between building design and room conditioning, as well as the systems this involves. The key levers of energy-efficient and sustainable design and building are conveyed and explained on the basis of project examples.

The lecture Supplying Buildings with Renewable Energy covers the following topics:

- Introduction: Links between energy efficiency – saving energy – renewable energy
- Renewable Energy Act (Erneuerbare-Energien-Gesetz), Renewable Energy Heat Act (Erneuerbare-Energien-Wärme-Gesetz)
- Principles and strategies of supplying heat and power based on renewable energy to buildings. Topics include: Potentials and typical combinations of several forms of renewable energy used to supply buildings; ecological and economic assessment of the systems involved
- Examples based on different building concepts (for example, energy-plus buildings)
- Local and district heating: Possible strategies for using renewable energy; limits of decentralized energy supply

### **Intended Learning Outcomes:**

Students who have successfully completed the module are able to:

- describe and apply the correlations between building shell design, indoor climate and comfort requirements
- define the necessary room conditioning systems and methods
- apply the terms of the Renewable Energy Act (Erneuerbare-Energien-Gesetz) and the Renewable Energy Heat Act (Erneuerbare-Energien-Wärme-Gesetz)
- describe the links and correlations ranging from energy production to the supply of energy to buildings
- plan typical concepts for supplying renewable energy to buildings, including the foundations for ecological and economic assessments
- understand the foundations of designing district heating grids

### **Teaching and Learning Methods:**

The lecture conveys knowledge about various renewable-energy technologies as well as the skills needed to assess them. While working on specific assignments in self-study, the students gain a deeper understanding of various applications. The lecture topics are relevant to the examination and complement each other in terms of content. The students acquire detailed knowledge about the application and specific characteristics of different energy supply components based on practical examples in order to develop optimal solutions within the integrated design process that takes account of the respective building concept.

### **Media:**

Projector presentations, films, documents, exercises, tests

### **Reading List:**

Sterner, Michael ; Stadler, Ingo: Energiespeicher - Bedarf, Technologien, Integration. 2. Aufl.. Berlin Heidelberg New York: Springer-Verlag, 2017.

Bernhard Lenz: Nachhaltige Gebäudetechnik : Grundlagen - Systeme - Konzepte. Berlin: Walter de Gruyter, 2012.

Pistohl, Wolfram ; Rechenauer, Christian ; Scheuerer, Birgit: Handbuch der Gebäudetechnik : Planungsgrundlagen und Beispiele. 1. Allgemeines, Sanitär, Elektro, Gas. 8. Aufl.. München, Unterschleißheim: Werner, 2013.

Pistohl, Wolfram ; Scheuerer, Frank ; Rechenauer, Christian: Handbuch der Gebäudetechnik : Planungsgrundlagen und Beispiele. 2. Heizung, Lüftung, Beleuchtung, Energiesparen. 8. Aufl.. München, Unterschleißheim: Werner, 2013.

### **Responsible for Module:**

Werner Lang sekretariat.enpb.bgu@tum.de

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Erneuerbare Energieversorgung von Gebäuden (Vorlesung, 4 SWS)

Lang W [L], Kierdorf D, Kleeberger M, Lang W, Schwering K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU62053: Sustainable Lighting | Nachhaltige Lichttechnik

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module exam consists of a written exam. The aim of the written exam is verify to what extent participants have achieved the learning objectives. The latter are both module-related and competence-oriented. The duration of the written exam is 90 min. No aids are allowed with the exception of a calculator. The aim of the written exam is to test, in an application-oriented way, whether students included the use of sustainable lighting concepts in the planning process. Important: Tthe exam will take place online via Moodle. The exam is not proctored, all aids are allowed.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

keine

#### Content:

The foundations of the physiological and psychological perception of light are taught (colour of light, colour reproduction, direct and indirect effects of light). In addition, the photometric laws and the parameters and units of lighting technology are conveyed. The priority is always the aspect of sustainable lighting technology. Daylight-dependent design as well as foundations of lamp and lighting technology are imparted, as well as the foundations of assessing simulation tools.

#### Intended Learning Outcomes:

After completing this course successfully, students are able to

- understand foundations of lighting, including the basics of photometry, the perceptive function of the eye, artificial lighting technologies (lamps, lights, operating units), and daylight technology
- apply daylight technology, taking account of issues related to interior and façade design as well as the integration of artificial lighting systems

- understand the foundations of planning artificial lighting systems and natural lighting
- familiarise themselves with calculation methods (light simulation methods for artificial and natural light) and assessment methods (glare and energy)
- understand the basic functions of the eye as well as factors that have an effect on the visual function and perception
- understand the foundations of light and the environment: energy, sustainability, EU directives
- analyse tools, variables of lighting, lighting materials.

The students are able to perceive and interpret the links and the tensions between persons, light and space. They know the basic technical concepts of lighting and know how to use them.

### **Teaching and Learning Methods:**

The course is held in the form of a classical lecture, part of which in a block. Lectures, presentation and blackboard work, experiments on photometric parameters are presented. Excursions are planned.

### **Media:**

Lecture slides, PowerPoint presentation, demonstration, software-based work on a case study, computer-assisted presentation for the lecture, lecture script, experiments on photometric parameters

### **Reading List:**

Gall, Dietrich: Grundlagen der Lichttechnik : Kompendium. 2. überarb.. München: Pflaum, 2007.  
Ulmann, Philippe P.: Licht und Beleuchtung : Handbuch und Planungshilfe. Berlin: DOM publishers, 2015.  
Hentschel, Hans J: Licht und Beleuchtung : Theorie und Praxis der Lichttechnik. 4. Aufl.. Heidelberg: Hüthig, 1994.

### **Responsible for Module:**

Werner Lang sekretariat.enpb.bgu@tum.de

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Nachhaltige Lichttechnik (Vorlesung, 4 SWS)

Lang W [L], Meier-Dotzler C, Schwering K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU62059: Application of an Life Cycle Assessment for Civil Engineering | Anwendung einer Lebenszyklusanalyse für Bauingenieurwesen

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a scientific paper including a short presentation.

In the wiss. (30-40 pages) the students show whether they are able to reproduce a concrete application of a life cycle analysis (LCA) on an existing or planned building in a scientifically correct way. The aim of the paper is to examine to what extent a know. The elaboration aims at checking to what extent a scientific analysis of the task is carried out under the aspects of the application of target-oriented scientific methods. The concrete application of a life cycle analysis (LCA) to a building is based on an example project.

In a short presentation (approx. 10 min.) the students show that they are able to rhetorically reproduce the facts and that they are able to engage in a dialogue with the audience on the topic. The examination performance takes place online: the scientific paper is uploaded via Moodle and the presentations take place via ZOOM.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The successful participation in the module LCA BV360009

#### Content:

The content of the module Application of a Life Cycle Analysis (LCA) consists of

- Teaching the basics of a building LCA
- Mediation of software knowledge for the implementation of a LCA
- Calculation and evaluation of energy and CO<sub>2</sub> balances at material and component level
- Identification of potentials for reducing environmental impacts

- Students work independently on a given project
- Presentation of the elaborated results in a lecture and elaboration of a seminar paper

### **Intended Learning Outcomes:**

After participating in the module, the students are able to

- reflect a sound basic understanding of life cycle assessment
- to adequately evaluate the results of the life cycle assessment.
- to analyse energy and CO<sub>2</sub> balances.
- To understand the most important ecological parameters of a building.
- to apply calculations in a life cycle assessment software (eLCA) to specific buildings.
- to analyse existing building structures with regard to the components and materials used over all life cycle phases and to develop optimisation proposals
- Develop recommendations for ecological optimisation of a building design, taking into account all life cycle phases.
- to reflect a life cycle analysis on a building in a scientifically correct way.

### **Teaching and Learning Methods:**

The module consists of one seminar. In the seminar there are individual input lectures to give the students the necessary basics about life cycle assessment and life cycle analysis. Based on the lectures, the application of this knowledge takes place in the seminar using a concrete example project. The students work on the tasks in groups and are supervised by the teacher (group work, seminar). The participants develop sustainable building components and identify the associated effects on the building and the environment, focusing on the application of a life-cycle approach to the concrete building and understanding the most important adjustment screws. It is particularly important to develop and answer ecological questions in early planning phases on a project-specific basis.

### **Media:**

Power Point, eLCA

### **Reading List:**

DIN, ENISO. 14044: 2006-10 Umweltmanagement–Ökobilanz–Anforderungen und Anleitungen. DIN Deutsches Institut für Normung eV Berlin: Beuth Verlag, 2006. DIN, ENISO. 14040: Umweltmanagement–Ökobilanz–Prinzipien und allgemeine Anforderungen. Deutsche Fassung der EN ISO, 1997, 14040. Jg., Nr. 1997, S. 16. KÖNIG, Holger, et al. Lebenszyklusanalyse in der Gebäudeplanung. Institut für internationale Architektur-Dokumentation, München, 2009.

### **Responsible for Module:**

Prof. Dr.-Ing. Werner Lang sekretariat.enpb.bgu@tum.de

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Anwendung einer Lebenszyklusanalyse (Seminar, 4 SWS)

Lang W [L], Schwering K, Takser I, Theilig K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66016: Hydrogeologic and Hydro Chemical Lab Course | Hydrogeologisches Fluid- und Hydrochemisches Laborpraktikum

Version of module description: Gültig ab summerterm 2014

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>75   | <b>Contact Hours:</b><br>105         |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung ist eine Laborleistung, die erstens aus einem schriftlichen Laborbericht besteht, in dem die Studierenden die durchgeführten Versuche in den Praktika „Hydrochemisches und Hydrogeologisches Laborpraktikum“ dokumentiert festhalten sollen. Die Studierenden zeigen damit, inwieweit sie in der Lage sind, eigenständig die gängigen Laborversuche zur Charakterisierung und Quantifizierung von Strömungsprozessen sowie von Grundwässern durchzuführen, auszuwerten und anschließend die gewonnenen Werte mit den Werten aus der Literatur zu vergleichen und zu bewerten. Zur Laborleistung zählt zweitens ein mündliches Testat von insgesamt 30 Minuten (während bzw. vor zwei zufällig ausgewählten Versuchen), in dem die Studierenden über die hydrogeologischen und hydrochemischen Methoden und Analyseverfahren befragt werden und damit überprüft wird, inwiefern die Studierenden in der Lage sein werden, diese bei Durchführung und Auswertung der Versuche im Labor anwenden zu können und inwieweit sie sich mit den sicherheitsrelevanten Aspekten der Versuchsaufbauten auseinander gesetzt haben und damit eine sichere Versuchsdurchführung gewährleisten können. Schriftlicher Laborbericht und mündliches Testat gehen mit einer Gewichtung von 50% in die Modulendnote der Laborleistung ein.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Das Modul Hydrogeologische Methoden (BGU66017) sollte begleitend besucht werden; Grundkenntnisse der Hydrogeologie aus dem BSc Geowissenschaften.

#### Content:

Im Kurs Hydrogeologisches Fluid-Laborpraktikum werden Laborversuche zur Charakterisierung und Quantifizierung von Strömungsprozessen in porösen Medien durchgeführt. Dies

umfasst Versuche um folgende Kennwerte bzw. Parameter zu bestimmen: Porosität und Speicherkoeffizient; Dichte und Viskosität von Fluiden; Hydraulische Durchlässigkeit; Mehrphasenfließen; kapillarer Aufstieg und Kapillarsperre. In diesem Kurs können Sie auch zusätzliche Qualifikationen in der Markierungstechnik erwerben. Wir vermitteln Ihnen dazu spezielles Wissen über die chemischen Eigenschaften von fluoreszierenden und nicht fluoreszierenden Farbstoffen, zeigen Ihnen wie Tracerversuche in verschiedenen geologischen Systemen und im Labor durchzuführen sind, wie Fluoreszenzfarbstoffe zu messen und Tracerdurchgangskurven mathematisch auszuwerten und zu interpretieren sind. Im Kurs Hydrochemisches Laborpraktikum werden hydrochemische Methoden zur Charakterisierung von Grundwässern angewendet: Bestimmung der Konzentrationen von Kationen und Anionen; Bestimmung der Konzentration von Fluoreszenzfarbstoffen; Bestimmung von Verteilungsgleichgewichten zu nichtwässrigen Flüssigkeiten und Feststoffen.

### **Intended Learning Outcomes:**

Nach der Teilnahme an der Modulveranstaltung sind die Studierenden in der Lage grundlegende hydrogeologische und hydrochemische Analysenverfahren selbständig durchzuführen und die dabei gewonnenen Daten auszuwerten, sowie die gewonnenen Ergebnisse zu beurteilen. Somit können sie Grundwasser mit aktuellen Analysenverfahren charakterisieren und die Strömung von Grundwasser quantitativ prüfen. Zudem sind die Studierenden in der Lage, die Versuchsdurchführung in einem Laborbericht zusammenfassend zu beschreiben und die Ergebnisse im Vergleich mit Literaturangaben zu diskutieren und in anschaulichen Diagrammen zu illustrieren. Die Studierenden werden geschult, sich kritisch mit vorgegebenen Anleitungen, Arbeitsanweisungen und Versuchsaufbauten auseinander zu setzen und diese zu verbessern.

### **Teaching and Learning Methods:**

Die Laborversuche werden mit Hilfe des Laborskriptes unter Anleitung der Dozenten und weiterer wissenschaftlicher Mitarbeiter/-innen von den Studierenden in Kleingruppen selbständig durchgeführt und ausgewertet. Die erzielten Ergebnisse werden täglich in Form von Kurzpräsentationen am jeweiligen Versuch dargestellt.

### **Media:**

PowerPoint-Präsentation, Skript, Übungsskript (Labor), eigenständige Versuche im Labor (Laborpraktikum)

### **Reading List:**

LANGGUTH & VOIGT (2004): Hydrogeologische Methoden, Springer.  
FETTER (2001): Applied Hydrogeology, Prentice-Hall.  
KUCHLING (1999): Taschenbuch der Physik, Fachbuchverlag Leipzig.  
SIGG & STUMM (2011): Aquatische Chemie, Teubner; Zürich.

### **Responsible for Module:**

Florian Einsiedl (f.einsiedl@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrogeologisches Praktikum (LV0581) (Übung, 2,5 SWS)

Baumann T

Hydrogeologisches Fluid-Laborpraktikum (Tracerhydrogeologie) (Übung, 2,5 SWS)

Einsiedl F, Rein A

Hydrochemisches Praktikum (Praktikum, 3 SWS)

Haisch C ( Popp C ), Ivleva N

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66022: Groundwater Hydraulics | Grundwasserhydraulik

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module is validated by a written exam (90 min). In the written exam the students demonstrate their ability to understand basic principles in groundwater hydraulics (basic terms of ground water hydraulics, mathematical models to describe the water movement within the porous medium (Darcy's Law, potential flows), continuity for confined and unconfined aquifers, differential equations describing subsurface flows and their solutions) and apply these principles on simplified engineering and hydrogeological problems. Besides the students have to solve arithmetic problems stemming from hydrogeological case studies and performed hydraulic field tests to train their skilled theoretical knowledge. In the written exam, a hand-written A4 sheet is allowed as auxiliary means together with a non-programmable pocket calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic understanding of Hydrogeology, Mathematics, Physics and Chemistry is recommended. Students should be interested in working with mathematical models and in applied hydrogeology. It is mandatory that students have attended successfully the module Hydromechanik (B.Sc.) or an equivalent and have some basics in geology (Introduction to Geology, BGU67002). It is recommended that students have fundamental skill in Excel and Matlab or a similar programming language.

#### Content:

In the module are taught the fundamentals of Groundwater Hydraulics and the essential elements of Advanced Hydrogeology:

Groundwater Hydraulics:

- Fundamental concepts and terms in Groundwater Hydraulics
- Fundamentals and flow in a porous medium (Darcy's law and generalizations)

- Conservation laws (differential equations) for mass and momentum in confined and unconfined groundwater aquifers
- Solutions of the differential equations in simple flows (uniform flow, flow towards a well, dimensioning of a well)
- Unsteady flow towards a well, pumping test
- Fundamentals of numerical methods to solve groundwater flows

**Advanced Hydrogeology:**

- Fundamentals of water flow in the saturated zone (Darcy's law)
- Analysis of pump tests in complex porous aquifers
- Analysis of pump tests in fractured rocks with matrix porosity (Double-porosity systems)
- Soil water transport
- Flooding and feedback to groundwater
- Redox processes in a river (nitrogen cycle)

**Intended Learning Outcomes:**

After participating in the module, the students are able to:

- understand and apply basic concepts in groundwater hydraulics and solve complex hydrogeological problems in order to analyse groundwater hydraulic problems and evaluate groundwater resources and flow, to interpret hydraulic tests in porous and fractured groundwater media and to understand chemical field data
- apply mathematical models to describe simplified groundwater flow and hydrogeological problems
- evaluate and interpret hydraulic field tests (including pumping tests in unconsolidated and consolidated rock) concerning storativity and transmissivity of the aquifer
- analyse biogeochemical processes in aquifers related to the nitrogen cycle
- describe hydraulic questions by using mathematical equations and implement them in models

**Teaching and Learning Methods:**

The module Groundwater Hydraulics consists of a lecture and a lecture with integrated exercises. Groundwater Hydraulics and Advanced Hydrogeology. The basic knowledge in groundwater hydraulics is taught by class room lectures and tutorials with exercises examples. The lecture is accompanied by a written script, homework exercises and matlab scripts which the students use to achieve programming skills.

The underlying teaching philosophy of the lecture Advanced Hydrogeology is problem-based learning. The core of the courses consists of a series of tutorials (6), which should expose the students to important hydrogeological questions, problems and methodologies. Each scientific topic will be started with a thematic refresher and a lecture. After the lecture there will be a tutorial and this tutorial trains the students' expertise by having 'hands-on' the models (self-programmed models in spreadsheets and professional software for data interpretation). This means students are working on the tutorials in class (computer room) in order to actively learn on formulating and solving problems in the field of applied hydrogeology and biogeochemistry. At the end of each lecture a small group of students will discuss the results of the tutorial by short Power Point presentations.

**Media:**

Power-point presentation, black board, calculation exercises, pc-lab, discussion, recommended literature

**Reading List:**

Fetter CW (2001): Applied Hydrogeology, 4th ed. Prentice Hall, New Jersey, 598 pp.  
Langguth HR, Voigt R (2004): Hydrogeologische Methoden. 2. Ed, Springer, Berlin.  
Fetter, CW (1999): Contaminant Hydrogeology, 2nd ed. Prentice Hall, New Jersey, 500 pp. (1st edition: 1993).  
Domenico PA, Schwartz FW (1998): Physical and chemical hydrogeology. 2nd edition, Wiley.  
Appelo CAJ, Postma D (2006): Geochemistry, groundwater and pollution. Balkema, Leiden.  
Kinzelbach W, Rausch R (1995): Grundwassermodellierung - Eine Einführung mit Übungen. Borntraeger, Berlin, Stuttgart, 283 pp.  
Holzbecher E (1996): Modellierung dynamischer Prozesse in der Hydrologie - Grundwasser und ungesättigte Zone. S. Springer, Berlin, 364 pp.  
Rausch R, Schäfer W, Wagner Ch (2002): Einführung in die Transportmodellierung im Grundwasser. Borntraeger, Berlin, Stuttgart, 183 pp.

**Responsible for Module:**

Prof. Dr. Florian Einsiedl, f.einsiedl@tum.de, Chair of Hydrogeology

**Courses (Type of course, Weekly hours per semester), Instructor:**

Vertiefung Hydrogeologie für Umweltingenieure (Vorlesung mit integrierten Übungen, 2 SWS)  
Einsiedl F, Rein A, Wunderlich A

Grundwasserhydraulik (Vorlesung, 2 SWS)

Manhart M, Unglehart L

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### **BGU66023D2: The Saturated and the Unsaturated Zone: Process Understanding and Modelling | Die gesättigte und ungesättigte Zone: Prozessverständnis und Modellierung**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120   | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination consists of a project work.

Students will complete a study project, containing the analysis of given hydrogeological problems and related tasks. The study project will be done in groups. Each group has to accomplish a written report on the project work (to be submitted after the course), and this report will be graded. The study project and report consists of two equally weighted parts. The first part shall contain a parameterized numerical groundwater model (FEFLOW). The second part includes laboratory work and a parameterized model for unsaturated flow and transport in MATLAB.

Results obtained with these models should be described, discussion of the findings should be done and conclusions drawn, concerning the posed question/problem. Aims of this examination include to verify that students have understood basic concepts of flow and transport processes in saturated and unsaturated porous media and that they are able to apply those concepts for the solution of problems. By being exposed to typical hydrogeological questions, the ability of students building up an own numerical model and to “translate” hydrogeological conditions into professional numerical flow and transport models will be measured, as well as the ability to carry out simulations using these model and to interpret the results with respect to hydraulic processes.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Basic understanding of Hydrogeology, Geology, Environmental Geology, Mathematics, Physics and Chemistry is recommended. Students should be interested in working with mathematical models. It is recommended that students have visited module Groundwater Hydraulics, environmental monitoring, fluid mechanics (e.g. the BSc courses Grundmodul Hydrologie, Umweltmonitoring und

Risikomanagement, Fluid Mechanics), and Environmental Geology (BV000118) and Introduction to Geology

**Content:**

- Principles of groundwater movement, analysis of factors influencing groundwater flow
- Examples for applying groundwater models
- Acquiring and processing data for model input; interpolation techniques; data quality evaluation
- Setup of a hydrogeological model
- Numerical methods in groundwater modelling
- Setup of a numerical groundwater model; model discretization; boundary conditions; model parameterization
- Running simulations; model calibration and validation
- Interpretation and post-processing of results
- Hydrological surface processes driving soil moisture content
- Derivation of the flow equation in the unsaturated zone
- Introduction to implicit and explicit numerical methods for the solution of the unsaturated zone flow equation
- Flow in the unsaturated zone with OHWM
- Model Calibration, Inverse modelling
- Development of Matlab scripts for the solution of selected exercises

**Intended Learning Outcomes:**

A student who has met the objectives of the course will be able to:

- apply simple groundwater flow and transport simulations by building an own FEFLOW model in order to describe and analyse water resources and flow in the saturated zone
- insert geological information to the numerical groundwater model
- evaluate simulations with respect to real observations, data and model uncertainties
- to understand complex hydrogeological problems and to describe them mathematically
- evaluate and interpret hydraulic field tests (including pumping tests in unconsolidated and consolidated rock)
- analyse biogeochemical processes in aquifers related to the nitrogen and sulphur cycle
- describe hydraulic questions by using mathematical equations and implement them in models
- to understand the basic processes controlling hydrological processes in the unsaturated zone
- to apply the flow equation for the unsaturated zone
- to create flow and transport modelling based on field measurements
- to apply the following tools: MATLAB and OHWM

**Teaching and Learning Methods:**

The module consists of a lecture and exercise. The underlying teaching philosophy of the module is problem-based learning. The core of the courses consists of a series of tutorials, which should expose the students to important questions, problems and methodologies. The tutorials are supported by lectures, discussion and focused reading.

Each scientific topic will be started with a thematic refresher and a lecture. After the lecture there will be a tutorial, and this tutorial trains the students' expertise by having 'hands-on' the models

(self-programmed models in spreadsheets and professional groundwater modelling software). This means students are working on the tutorials in class (computer room) in order to actively learn on formulating and solving problems in the field of hydrogeology, groundwater-soil-plant interactions and subsurface contamination.

**Media:**

Power-point presentation, black board, movies, pc-lab, discussion, recommended literature

**Reading List:**

Fetter CW (2001): Applied Hydrogeology, 4th ed. Prentice Hall, New Jersey, 598 pp.  
Langguth HR, Voigt R (2004): Hydrogeologische Methoden. 2. Ed, Springer, Berlin.  
Fetter, CW (1999): Contaminant Hydrogeology, 2nd ed. Prentice Hall, New Jersey, 500 pp. (1st edition: 1993).  
Domenico PA, Schwartz FW (1998): Physical and chemical hydrogeology. 2nd edition, Wiley.  
Appelo CAJ, Postma D (2006): Geochemistry, groundwater and pollution. Balkema, Leiden.  
Kinzelbach W, Rausch R (1995): Grundwassermodellierung - Eine Einführung mit Übungen. Borntraeger, Berlin, Stuttgart, 283 pp.  
Holzbecher E (1996): Modellierung dynamischer Prozesse in der Hydrologie - Grundwasser und ungesättigte Zone. S. Springer, Berlin, 364 pp.  
Rausch R, Schäfer W, Wagner Ch (2002): Einführung in die Transportmodellierung im Grundwasser. Borntraeger, Berlin, Stuttgart, 183 pp.  
Chiang, W.-H., & Kinzelbach, W. (2001). 3D-Groundwater Modeling with PMWIN (With CD-ROM). Springer. Retrieved from <http://www.amazon.com/3D-Groundwater-Modeling-PMWIN-With-CD-ROM/dp/3540677445>  
Holzbecher, E. (2012). Environmental Modeling: Using MATLAB. Springer.  
J. Bear, Hydraulics of Groundwater, McGraw-Hill, New York, 1979  
P.A. Domenico, F.W. Schwartz, Physical and Chemical Hydrogeology, J. Wilson & Sons, New York, 1990  
"PEST- Model interdependent parameter estimation users manual. Watermark computing. Australia  
Poeter, E. P. and M. C. Hill, 1998. Documentation of UCODE, a computer code for universal inverse modeling, U.S. Geological Survey, Water-Resources Investigation Report 98-4080

**Responsible for Module:**

Dr. Arno Rein, [arno.rein@tum.de](mailto:arno.rein@tum.de), Chair of Hydrogeology

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modelling Processes in the Vadose Zone (Vorlesung, 2 SWS)  
Chiogna G [L], Chiogna G

Grundwasser-Modellierung 1 (Übung, 2 SWS)

Rein A, Zoßeder K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66024D2: Advanced Groundwater Modelling for Environmental Engineers | Fortgeschrittene Grundwassermodellierung für Umweltingenieure

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105   | <b>Contact Hours:</b><br>75                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a project work.

Students will complete a project work containing the analysis of given case studies on hydrogeological and hydraulic situations, subsurface contamination and related questions. This is to be done with help of mathematical modeling.

By exposing the students to defined “real world” hydrogeological cases, the project work measures the student’s competence to describe, analyze and evaluate hydrogeological problems with help of mathematical modeling. Students have to transfer and apply their knowledge obtained during the module. This includes an understanding of relevant processes in the soil-groundwater-plant system (water flow, contaminant transport and fate) and of interactions between groundwater and surface water. Adequate mathematical models have to be chosen and applied, and used models and model simulations have to be documented in the project work report. Based upon the model simulations, evaluations have to be done concerning hydraulic conditions and contaminant transport/fate in groundwater, soil and plants as well as concerning hydraulic interactions between groundwater and surface water. Obtained model simulations have also to be evaluated with respect to plausibility (comparison to available site information and measured data).

Project work will be done in groups. Each group has to accomplish a written report on the project work, and this report will be graded. The project work and report consists of two parts corresponding to the two courses. The report covers 20-30 pages in total. In order to recognize individual contributions, students shall document their contribution to subtasks within the project work and respective chapters of the report. The reports shall contain problem statements, results and findings concerning the case studies, as well as a discussion of the findings and a presentation of applied methods.

#### Repeat Examination:

Next semester

**(Recommended) Prerequisites:**

Basic understanding of Hydrogeology, Mathematics, Physics and Chemistry is recommended. Students should be interested in working with mathematical models. It is recommended that students have visited one of the following modules: BV660006 Hydrogeology I (Hydrogeologie I), BV660002 Groundwater Flow and Transport (Strömung und Transport).

**Content:**

This module deals on modeling hydrological and chemical processes in the soil-groundwater-plant system, as well as on modeling hydraulic exchange and feedback mechanisms between groundwater and surface water. Topics include:

Course Groundwater-Soil-Plant-Interaction:

- Soil and unsaturated zone (characteristics and processes)
- Plant physiology and functionality, plant-related processes in the environment
- Sorption and diffusion, microbes in the subsurface (microbial growth and degradation)
- Soil water balance and leaching, evaporation and transpiration, contaminant fate/transport in the unsaturated zone and within plants
- Set-up and application of analytical and water balance models for the soil-groundwater-plant system, for analyzing and evaluating water availability/flow and pollutant fate

Course Groundwater Modeling (Advanced):

- Contaminant transport in groundwater (processes and their mathematical description)
- Set-up and parameterization of analytical and numerical contaminant transport models, model application and interpretation of results
- Exchange and feedback mechanisms between groundwater and surface water and coupling of model codes
- Parameterization and application of the coupled groundwater-surface water model approach
- Evaluation of hydraulic situations with help of the simulation results

**Intended Learning Outcomes:**

A student who has met the objectives of the course will be able to:

- understand relevant processes in the soil-groundwater-plant system with respect to the water budget and contaminant transport and fate
- describe related environmental processes mathematically and develop baseline simulation models
- analyze hydraulic conditions and contaminant transport/fate in groundwater, soil & plants with help of modeling
- understand and evaluate hydraulic interactions between groundwater and surface water
- understand and apply the coupling of numerical surface water and groundwater models
- compare model calculations with observations and available site data and evaluate the obtained simulation results

**Teaching and Learning Methods:**

The module consists of two lectures with integrated exercises. The underlying teaching philosophy of the module is problem-based learning. The core of the courses consists of a series of tutorials,

which should expose the students to important questions, problems and methodologies. The tutorials are supported by lectures, discussion and focused reading.

Each of the scientific topics will be trained and discussed for one to three weeks with lectures and tutorials. Each topic will be started with a thematic refresher and a lecture. After the lecture there will be a tutorial, and this tutorial trains the students' expertise by having 'hands-on'. This means students are working on the tutorials in class (computer room) in order to actively learn on formulating and solving problems in the field of hydrogeology, groundwater-soil-plant interactions, groundwater-surface water interactions and subsurface contamination.

At the final part of the two courses (the last one or two sessions), case studies on hydraulic situations and subsurface contamination to be analyzed will be handed out (project work). Students will start with the project work in groups under supervision, where feedback will be given to each group by one-to-one discussions during the contact hours. Each group has to accomplish a written report on the project work at the end of the module (details see above). Working in groups trains the students' competence to carry out and complete their task (solving a hydrogeological problem) in a team. Individual contributions shall nonetheless be recognizable: students shall document their contribution to subtasks within the project work, reflected in respective chapters of the report.

#### **Media:**

Moodle e-learning platform, presentations, exercise hand-outs, pc-lab, recommended literature

#### **Reading List:**

Scheffer F, Schachtschabel P (2010): Lehrbuch der Bodenkunde. Springer, Berlin. (Older editions: Enke, Spektrum).

Trapp S, Matthies M (1998): Chemodynamics and Environmental Modeling: An Introduction. Springer, Berlin (German edition: Dynamik von Schadstoffen - Umweltmodellierung mit CemoS: Eine Einführung. Springer, Berlin, 1996)

Trapp S, McFarlane JC (1995): Plant Contamination. Lewis Publishers, London.

Holzbecher E (1996): Modellierung dynamischer Prozesse in der Hydrologie - Grundwasser und ungesättigte Zone. Springer, Berlin.

Schwarzenbach RP, Gschwend PM, Imboden DM (2002): Environmental Organic Chemistry. 2.Ed., Wiley, New York.

Anderson, M., Woessner, W. (1992): Applied Groundwater Modelling. Academic Press, Inc.

Kinzelbach, W. & Rausch, R. (1995): Grundwassermodellierung – Eine Einführung mit Übungen. Borntraeger, Stuttgart.

Kovarik, K. (2000): Numerical Models in Groundwater Pollution. Springer, Berlin.

Rausch, R., Schäfer, W. & Wagner, Ch. (2002): Einführung in die Transportmodellierung im Grundwasser. Borntraeger, Stuttgart.

#### **Responsible for Module:**

Arno Rein, arno.rein@tum.de

#### **Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrogeologische Fallbeispiele, Grundwasser-Boden-Pflanzen-Interaktion (Vorlesung mit integrierten Übungen, 2 SWS)

Rein A

Grundwassermodellierung (Fortgeschrittene) (Vorlesung mit integrierten Übungen, 3 SWS)

Zoßeder K, Rein A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66025: Applied Hydrogeology for Environmental Engineers | Hydrogeologie in der Praxis für Umweltingenieure

Version of module description: Gültig ab winterterm 2016/17

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Prüfungsleistung besteht aus einer schriftlichen Projektarbeit, die die Studierenden in Gruppen (drei bis vier Personen, abhängig von der Teilnehmerzahl) anfertigen und nach der Vorlesungszeit abgeben. Die Projektarbeit besteht aus einem zu bearbeitenden Fallbeispiel.

Mit der Projektarbeit wird überprüft, inwieweit die Studierenden in der Lage sind, anhand konkreter Fallbeispiele (jede Gruppe erhält ein separates Thema) aus der hydrogeologischen Praxis komplexe hydrogeologische Probleme zu erkennen und zu analysieren, adäquate Methoden zum Beantworten hydrogeologischer Fragestellungen anzuwenden und die gewonnenen Ergebnisse zu bewerten. Durch die Gruppenarbeit wird zudem die soziale Kompetenz der Studierenden geprüft, bei der Lösung berufspraktisch-relevanter Fragestellungen der angewandten Hydrogeologie, wie etwa die Erstellung eines hydrogeologischen Gutachtens, im Team ergebnisorientiert zusammenzuarbeiten.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Empfohlen sind Grundkenntnisse der Hydrogeologie, sowie der Mathematik, Physik und Chemie. Teilnehmer/Innen sollten an der Arbeit mit mathematischen Modellen interessiert sein. Empfohlene Lehrveranstaltungen im Vorfeld sind die Module BV660006 Abriss der Hydrogeologie und BV660002 Strömung und Transport.

#### Content:

Im Modul werden die Grundlagen für die praxisnahe Bearbeitung wesentlicher hydrogeologischer Arbeitsfelder (Altlastensanierung, Trinkwassergewinnung) vermittelt:

- Grundwasserbeschaffenheit (Grundlagenwiederholung)
- Probennahme (Boden, Grundwasser)



- Vorgehensweise bei der Begutachtung von Altlasten
- Bestehende Konzepte zur Sanierung von Boden und Grundwasser
- Wichtige (Berufs-)Zertifizierungen im Altlastenbereich
- Ausweisung von Trinkwasserschutzgebieten (Bemessungsverfahren, Antragsunterlagen, Schutzgebietsfestsetzung)
- Grundwassererschließung durch Brunnen und Quelfassungen (Vorerkundung, Planung, Ausschreibung, Baubetreuung, Pumpversuche, Datenerfassung, Auswertung, Analytik, Wasserrecht etc.)
- Erstellung hydrogeologischer Gutachten (Aufgabenstellung, Konzeptentwicklung, Angebotskalkulation, Datenerhebung, Projektdurchführung, Gutachten)

### **Intended Learning Outcomes:**

Nach der Teilnahme an der Veranstaltung beherrschen die Studierenden des Umweltingenieurwesens:

- die Grundlagen für die Erstellung eines hydrogeologischen Basisgutachtens, um diese in der hydrogeologischen praktischen Arbeit (z.B. im Ingenieurbüro) anzuwenden
- Gruppenarbeit bei der Lösung berufspraktisch-relevanter Fragestellungen der angewandten Hydrogeologie, wie etwa die Erstellung eines hydrogeologischen Gutachtens, im Team ergebnisorientiert anzuwenden.
- die Richtlinien und Vorgehensweise für Brunnenerschließungen, Quelfassungen und Ausweisung von Trinkwasserschutzgebieten anzuwenden

Desweiteren sind sie in der Lage:

- die Schritte in der Praxis (Datenrecherche, Probennahme, Datenbeurteilung, Dokumentation, Schlussfolgerung) und die entsprechenden wasserwirtschaftlich relevanten Regelwerke (WHG, Leitfäden, Merkblätter der Landesämter) für eine Beurteilung von Altlasten und von Sanierungskonzepten zu verstehen
- die berufsspezifischen Zertifizierungsmöglichkeiten im Altlastenbereich zu verstehen, um die beruflichen Anforderungen in der hydrogeologischen Praxis zu kennen.

### **Teaching and Learning Methods:**

Die Veranstaltung besteht aus einer Reihe von Vorlesungen, die mit praktischen Übungen ergänzt werden, wobei problembasiertes Lernen eine philosophische Grundlage bildet. Die Übungen spielen eine zentrale Rolle: Hier wird anhand von Praxisbeispielen die tatsächliche Anwendung der theoretischen Grundlagen der Hydrogeologie trainiert, welche wiederum in den Vorlesungsstunden vermittelt werden. In der Vorlesung werden zudem optional Gastvorträge von Fachleuten aus der Praxis zu speziellen Themen angeboten, wie etwa der Altlastensanierungspraxis oder den rechtlichen Grundlagen.

Die einzelnen Themen werden jeweils über 1-3 Wochen behandelt, wobei jedes Thema mit einer kurzen Auffrischung der hydrogeologischen Grundlagen begonnen wird. Hierbei werden die grundlegenden Fragestellungen im Plenum aktiv diskutiert. Daran schließen sich praktische Übungsstunden an, die eng mit Problemen aus der Praxis verbunden sind. Die Studierenden wenden hierbei hydrogeologische Konzepte/Methoden an, um aktiv die Formulierung und Lösung von typischen Problemen in der Praxis zu lernen, die im Bereich der Hydrogeologie und

Untergrundkontamination auftreten können. Die Übungen werden von den Studierenden während des Kurses unter Betreuung bearbeitet, wobei manche der Übungen zu Hause fertig gestellt werden sollen (in ca. 2 Stunden Eigenstudiumszeit; Besprechung in der darauffolgenden Sitzung). Am Schluss der Kurse (letzte ein bis zwei Termine) werden die Fallstudien ausgeteilt, die als Projektarbeit (Prüfungsleistung) gestellt sind. Die Studierenden beginnen in Gruppen von drei bis vier Personen daran zu arbeiten, wobei die Betreuer Feedback geben (individuelle Diskussionen mit den einzelnen Gruppen). Die Projektarbeiten stellen eine Synthese und Transfer-Anwendung der während des Kurses gelernten Methoden und (Bewertungs-)Techniken dar.

**Media:**

Powerpoint-Vortrag, Tafelbild, Übungsblätter, Übungen am Computer (Rechner-Raum), Auszüge aus der Literatur

**Reading List:**

LANGGUTH HR., Voigt R (2004): Hydrogeologische Methoden. 2. Ed, Springer, Berlin.

**Responsible for Module:**

Dr. Kai Zosseder, [kai.zosseder@tum.de](mailto:kai.zosseder@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrogeologie in der Praxis (Vorlesung mit integrierten Übungen, 2 SWS)

Zoßeder K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU66026: Shallow and Deep Geothermal Energy Use of Groundwater for environmental Engineers | Flache und Tiefe Geothermie von Grundwassersystemen für Umweltingenieure**

Version of module description: Gültig ab winterterm 2016/17

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Mit der Klausur (60 min) wird geprüft, inwieweit die Studierenden in Wissensfragen die physikalischen Grundlagen der Geothermie, die physikalischen, geologisch/hydrogeologisch relevanten Parameter und die geothermischen Prozesse beschreiben können sowie in praxisnahen Fragestellungen die Untersuchungs- und Berechnungsmethoden für die Planung und Auslegung oberflächennaher Systeme fallspezifisch anwenden, sowie die Ergebnisse aus der Datenauswertung von Feld- und Bohrdaten, auch hinsichtlich Unsicherheiten und Risiken in der Geothermie, analysieren und bewerten können.

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

Empfohlen sind Grundkenntnisse der Geologie (Einführung in die Geologie für Umwelting.), Hydrogeologie (Grundwasserhydraulik) und der Thermodynamik.

#### **Content:**

Im Modul werden den Studierenden die Grundlagen der Geothermie sowie die Vorgehensweise und andere wichtige Aspekte bei Planung, Bau und Betrieb von geothermischen Anlagen vermittelt. Die Inhalte sind im Einzelnen:

- Physikalischen Grundlagen des Wärmestroms im Untergrund
- Relevante Parameter zur Beschreibung geothermischer Systeme
- Lagerstättentypen geothermischer Systeme
- Verfahren zur Planung, Exploration und Gewinnung bei tiefen geothermischen Systemen

- Nutzungsvarianten von oberflächennahen geothermischen Systemen und ihre Planung und Auslegung
- Rechtliche Grundlagen bei der Nutzung von oberflächennaher und tiefer Geothermie
- Ökonomische Betrachtung von oberflächennahen Systemen
- Unsicherheiten und Risikoabschätzung bei geothermischen Nutzungen

### **Intended Learning Outcomes:**

Nach der erfolgreichen Teilnahme an den Modulveranstaltungen sind die Studierenden in der Lage:

- die Prozesse der Wärmeströmung im Untergrund hinsichtlich ihrer geothermischen Nutzung zu verstehen
- die Verfahren zur Erhebung und Auswertung von Daten (Felddaten, Bohrdaten) zu verstehen, welche die relevanten geothermischen Parameter abschätzen bzw. erheben.
- Verfahren zur Nutzung der oberflächennahen und tiefen Geothermie zu verstehen.
- Berechnungsmethoden zur Auslegung und Planung oberflächennaher Systeme anzuwenden, die Ergebnisse zu analysieren und zu bewerten.
- die Unsicherheiten und Risiken (z. B. Fündigkeits- und Bohrrisiken) in der Geothermie zu verstehen.

### **Teaching and Learning Methods:**

Das zu Grunde liegende Konzept des Moduls ist das problembasierte Lernen. Der Kern des Moduls besteht aus Lehrgesprächen mit Präsentationen zur Nutzung der tiefen und oberflächennahen Geothermie. Anschließend werden die Lerninhalte durch Übungen umgesetzt und vertieft werden. Die Übungen beinhalten Aufgaben zur Planung und Auslegung geothermischer Systeme und zum Verständnis der relevanten geologisch-thermischen Prozesse in der Geothermie. Hierbei werden Aufgaben gestellt, welche die Studierenden in selbstständiger Arbeitsweise analysieren sollen. Die Ergebnisse der Studierenden werden in der Gruppe diskutiert und der Lösungsweg aufgezeigt. Die Ergebnisse der Übungen werden den Studierenden auf der e-learning Plattform zur Verfügung gestellt um den Lösungsweg in der Nachbearbeitung überprüfen zu können. Die Vorlesung und Übung wird nach Bedarf und Möglichkeit durch Gastdozenten aus der Praxis unterstützt.

### **Media:**

Moodle e learning Plattform, wiki-Plattform, Power-Point Präsentationen, Übungsaufgaben am PC, Lehrgespräche, Diskussion, Gruppenarbeit

### **Reading List:**

BANKS, D. (2012): An Introduction to Thermogeology. – Ground source heating and cooling. 2nd Edition, 526 S., Wiley-Blackwell, Sussex.

DIPIPO, R. (2012): Geothermal Power Plants. – Principles, Applications, Case studies and Environmental Impact. – 600 S., Elsevier, Amsterdam.

GRANT, M. A. & BIXLEY, P. F. (2011): Geothermal Reservoir engineering. 2nd Edition, 359 S., Academic Press , Burlington.

HUENGES, E. (2010): Geothermal Energy Systems: Exploration, Development, and Utilization. - 463 S., Wiley VCH, Weinheim.

KALTSCHMIT, M., HUENGES, E. & WOLFF, H. [Hrsg.] (1999): Energie aus Erdwärme. – 265 S., Spektrum, Heidelberg.

KOENIGSDORFF, R. (2011): Oberflächennahe Geothermie für Gebäude. – 332 S., Fraunhofer IRB, Stuttgart.

OCHSNER, K. (2007): Geothermal Heat Pumps – A Guide for Planning and Installing. – 224 S., Cromwell Press, Trowbridge.

THOLEN, M. & WALTER-HERTKORN, S. (2008): Arbeitshilfen Geothermie. – 228 S., WVGW, Bonn.

**Responsible for Module:**

Kai Zosseder, [kai.zosseder@tum.de](mailto:kai.zosseder@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Einführung in die oberflächennahe und tiefe Geothermie (Vorlesung mit integrierten Übungen, 3 SWS)

Zoßeder K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU66029: Transport of Contaminants in Groundwater for Environmental Engineers | Transport von Schadstoffen im Grundwasser für Umweltingenieure

Version of module description: Gültig ab winterterm 2016/17

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In der Klausur (Hilfsmittel: Taschenrechner) zeigen die Studierenden ihre Fertigkeit zur problemlösungsorientierten Analyse und Bewertung von praxisrelevanten Fragestellungen zu Stofftransport im Grundwasser, Mehrphasenfließen, Einsatz und Auswirkungen von Kolloiden und Nanopartikeln. Die Studierenden stellen in Wissens- und Transferfragen sowohl ihr theoretisches Wissen in der Schadstoffhydrogeologie unter Beweis als auch die Fähigkeit, wissenschaftliche Messergebnisse quantitativ zu interpretieren und zu bewerten, eine Prognose für die Stoffausbreitung in gegebenen beispielhaften Szenarien zu entwickeln sowie die Resultate z.B. in Schemaskizzen und Profilschnitten anschaulich darzustellen und zu visualisieren.

Bei weniger als 4 Prüfungskandidaten werden die Kompetenzen in gleicher Weise mündlich geprüft.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Module W-10 Hydrochemie, P-10 Strömung und Transport (BV660002), sowie Grundkenntnisse in Hydrogeologie, Mathematik, Physik und Chemie aus dem Bachelorstudium.

#### Content:

Die Studierenden erlangen das notwendige Wissen und die Fertigkeiten um den Transport von Schadstoffen im Grundwasser quantitativ zu beschreiben und zu bewerten.

- Rechtliche Grundlagen für die Qualität von Grundwasser und Oberflächengewässern
- Transport von Wasserinhaltsstoffen im gesättigten und ungesättigten Milieu (Dispersion, Sorption, Abbau)

- Mehrphasenfließen,
- Transport von Kolloiden,
- Transporteigenschaften anorganischer und organischer Kontaminanten

### **Intended Learning Outcomes:**

Nach der Teilnahme an der Veranstaltung sind die Studierenden in der Lage:

- die Ausbreitung von Schadstoffen im Grundwasser zu quantifizieren und das Risiko von Grundwasserverunreinigungen schadstoffspezifisch zu bewerten.
- die Wechselwirkungen von anorganischen und organischen Schadstoffen im Grundwasserleiter zu verstehen,
- wissenschaftliche Experimente zur Quantifizierung des Transports von Schadstoffen zu verstehen, zu interpretieren und hinsichtlich der Übertragbarkeit zu bewerten,
- die Auswirkungen von technischen Maßnahmen, (z. B. Enteisung, Aufhärtung, Chlorierung) bei der Wasseraufbereitung auf das Verhalten von Schadstoffen zu verstehen und auf andere Fragestellungen (z. B. Mischung von oberflächennahen Grundwässern mit Tiefengrundwässern) zu übertragen,
- aktuelle Fragestellungen im Themenfeld Grundwasserqualität (z. B. Spurenstoffe im Mineralwasser, Auswirkungen von Hochwässern, Fracking, ...) wissenschaftlich aufzubereiten und auf Basis des erworbenen Wissens zu diskutieren.
- Ergebnisse aus wissenschaftlichen Untersuchungen zum Transport von Schadstoffen zu interpretieren, anschaulich darzustellen und zu visualisieren

### **Teaching and Learning Methods:**

Die Lerninhalte werden durch Vorträge (Lehrvortrag, wiss. Vortrag) und Lehrgespräche vermittelt. Die Studierenden erarbeiten für einzelne Schadstoffgruppen Datenblätter mit charakteristischen Eigenschaften (Transportverhalten, Persistenz, Toxizität) und tragen diese vor. Aktuelle Themen (z.B. Fracking) werden in Diskussionsformaten (pro/contra) wissenschaftlich aufbereitet.

### **Media:**

Vortrag, Gruppenarbeit an Fallstudien, Präsentation von Literaturstudien.

### **Reading List:**

APPELO, C.A.J, POSTMA, D. (2006) Geochemistry, Groundwater and Pollution, Balkema, Leiden.  
Clark & Fritz (1997): Environmental Isotopes in Hydrogeology.-398 S. Lewis Publisher.  
DOMENICO, SCHWARTZ (1998): Physical and chemical hydrogeology.- (Wiley).  
DVWK [HRSG.] (1989): Stofftransport im Grundwasser. 296 S.; Berlin (DVWK Schriften, 83).  
FETTER (2001): Applied Hydrogeology.- New Jersey (Prentice-Hall).  
FETTER (1998): Contaminant Hydrogeology, New Jersey (Prentice-Hall)  
MATHEß, G. (1994): Die Beschaffenheit des Grundwassers.- 499 S.; Berlin

### **Responsible for Module:**

Thomas Baumann, tbaumann@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Transport von Schadstoffen im Grundwasser (Vorlesung, 2 SWS)

Baumann T

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU66037: Case studies in Technical Hydrogeology | Technische Hydrogeologie in der Praxis

Version of module description: Gültig ab summerterm 2020

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150         | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a project work (approx. 45-50 pages) with a concluding presentation (approx. 30 minutes). In the project work the students analyse given hydrogeological problems in the form of a simulation game. The project work is carried out in groups and is structured as follows. The simulation game includes all phases of a hydrogeological site development (e.g. hydrogeological aspects of a sustainable development of an industrial area). At the beginning the students prepare a first offer in a simulated tendering procedure (5-8 pages, not graded). With this offer, they demonstrate that they are able to analyse and evaluate common technical problems in the fields of groundwater development, landfill technology, investigation and remediation of contaminated sites. In the next step, the students develop a sustainable hydrogeological concept for the industrial park (ca. 15 pages, 35% of the grade), and present a detailed plan for site development (ca. 25 pages, 50% of the grade). The students thus demonstrate both their theoretical knowledge of technical hydrogeology and their ability to clearly present and visualise technical issues in hydrogeology. The results of the project work are presented to the module participants at the end of the module. (15 % of the grade) This tests the students' ability to work out solutions to real hydrogeological problems and to present their knowledge and skills orally, precisely and in a structured way.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Empfohlen sind Grundkenntnisse der Geologie und Hydrogeologie, sowie der Mathematik, Physik und Chemie. Teilnehmer/Innen.

+ Hydrogeologie I (BGU66020 aus dem Bachelorstudiengang Geowissenschaften) oder vergleichbare Inhalte für Externe

+ Modul BV660002 Strömung und Transport

### **Content:**

- + Bau, Betrieb und Regenerierung von Grundwasserfassungen
- + Interpretation von Kamerabefahrungen
- + Trinkwasserschutzgebiete (Grundlagen, Geländearbeiten, Bemessungsverfahren, Antragsunterlagen, Schutzgebietsfestsetzung, Zusammenarbeit zwischen Ingenieurbüros und Behörden etc.)
- + Bau, Betrieb und Sanierung von Deponien
- + Auswirkungen technischer Grundwassernutzungen (Oberflächennahe Geothermie, Bewässerung und Wasserhaltung, Speichersysteme)
- + Wechselwirkungen Grundwasser/Oberflächenwasser
- + Rechtlicher Rahmen für die Altlastenbehandlung
- + Definition der Wirkungspfade Boden, Grundwasser, Pflanze, Mensch
- + Zertifizierungsmöglichkeiten in der Praxis
- + Erkundung von Grundwasserkontaminationen (Historische Erkundung, Vor- und Detailuntersuchung)
- + Beispiele aus der Praxis der Altlastenerkundung und Sanierung
- + Vulnerabilität des Grundwassers
- + Gefahrenabwehrmaßnahmen
- + Sanierungsverfahren für Grundwasserkontaminationen (Einkapselung, in situ Sanierung, Natural Attenuation)
- + Sanierungsverfahren für Bodenkontaminationen
- + Sanierung von multiplen Kontaminationen: Die ökologischen Großprojekte
- + Erstellung hydrogeologischer Gutachten (Fragestellung, Konzeptentwicklung, Datenerhebung, hydrogeologisches Modell, Gutachtenerstellung)

### **Intended Learning Outcomes:**

Nach der Teilnahme an den Modulveranstaltungen sind die Studierenden in der Lage die theoretischen Grundlagen und Methoden der technischen Hydrogeologie in der Praxis anzuwenden und umzusetzen. Sie verstehen insbesondere die Grundlagen und Methoden um:

- + eine Brunnenbohrung zu planen und die Erstellung technisch/wissenschaftlich zu überwachen,
- + Schäden an Brunnenbauwerken zu erkennen und Lösungsvorschläge zu entwickeln,
- + die technischen Anforderungen an die Errichtung und den Betrieb von Deponien anzuwenden,
- + die Auswirkung von Grundwassernutzungen zu bewerten,
- + kontaminierte Standorte und Grundwasserleiter zu erkennen,
- + die Untersuchung von kontaminierten Standorten zu planen,
- + die Untersuchung von kontaminierten Standorten zu bewerten,
- + die Untersuchung von kontaminierten Standorten technisch und wissenschaftlich zu überwachen,
- + Vorschläge für die Sanierung kontaminierter Standorte zu planen,
- + Sanierungsvarianten zu bewerten,
- + elementare Arbeitsabläufe in hydrogeologisch tätigen Ingenieurbüros zu verstehen,
- + Zertifizierungsmaßnahmen in der beruflichen Praxis zu bewerten,
- + die vorgestellten Themen in der späteren beruflichen Praxis selbstständig anzuwenden,

+ fächerübergreifende Themen und Probleme zu analysieren und geeignete Lösungsansätze z. T. in

Zusammenarbeit mit anderen Fachrichtungen zu erarbeiten,

+ theoretische Grundlagen mit praxisrelevantem Spezialwissen zu kombinieren.

### **Teaching and Learning Methods:**

Das Modul besteht aus einer Vorlesung und einer Vorlesung mit integrierten Übungen. Das zu Grunde liegende Konzept des Moduls ist das problembasierte Lernen. Der Kern des Moduls besteht aus Lehrgesprächen mit Präsentationen, die durch integrierte Übungen umgesetzt und vertieft werden. An praxisrelevanten Beispielen erarbeiten die Studierenden in beiden sich ergänzenden Veranstaltungen Lösungsansätze für typische hydrogeologische Fragestellungen. Es werden im Kurs sowohl klassische analoge Verfahren (Karten, Aufzeichnungen von Logs, Analysenberichte) als auch moderne digitale Verfahren am PC eingesetzt. Durch kurze Exkursionen und Baustellenbesuche wird die praktische Relevanz und Umsetzung vermittelt.

### **Media:**

Vortrag, Gruppenarbeit an Fallstudien, Präsentation von Literaturstudien, Videos von Fallbeispielen, Exkursion, Rechen- und Computerübungen, Lehrgespräch, Diskussion.

### **Reading List:**

LANGGUTH & VOIGT (2004): Hydrogeologische Methoden.- Berlin (Springer).

FETTER (2018): Applied Hydrogeology.- (Waveland Press).

BIESKE, RUBBERT, TRESKATIS (1998): Bohrbrunnen.- (Oldenbourg).

HOUBEN, TRESKATIS (2007): Water Well Rehabilitation and Reconstruction.- (McGraw-Hill).

ELLIS, SINGER (2007): Well logging for Earth Scientists.- Berlin (Springer).

FETTER (1993): Contaminant Hydrogeology.- (Prentice-Hall).

DOMENICO, SCHWARTZ (1998): Physical and chemical hydrogeology.- (Wiley).

APPELO, POSTMA (2006): Geochemistry, groundwater and pollution.- Leiden (Balkema).

HOLZBECHER, E. (1996): Modellierung dynamischer Prozesse in der Hydrologie - Grundwasser und ungesättigte Zone.- 364 S.; Springer, Berlin.

SCHWARZENBACH, R. P, GSCHWEND, P. M. & IMBODEN, D. M. (2002): Environmental Organic Chemistry. 2.Aufl., Wiley, New York.

### **Responsible for Module:**

Prof. Dr. Thomas Baumann (tbaumann@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Technische Hydrogeologie (Vorlesung, 2 SWS)

Baumann T

Hydrogeologie in der Praxis (Vorlesung mit integrierten Übungen, 2 SWS)

Zoßeder K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU67001: Landslides | Hangbewegungen

Version of module description: Gültig ab summerterm 2013

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

credit requirement: unsplit examination with pocket calculator and formulary; pass/fail credit requirement: 3 days mandatory field trips (3 x 8 h), protocol, not graded.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

As-built surveys and geodetical monitoring, fundamentals of geology

#### Content:

- Definition, terms & classification
- Landslide types and processes
- Landslide causes and triggers
- Case studies Goldau, Rufi, Grätli, Vajont, Elm
- Investigation and analysis of landslides
- Mapping of phenomena, Hazard & risk maps
- Monitoring techniques, early warning systems
- Case study Sudelfeld, research project alpEWAS
- Remote sensing reconnaissance
- Principles of risk assessment for natural hazards
- Assessing the probability of landslide hazards
- Vulnerability and exposure to landslide hazards
- Cost-benefit optimization of mitigation measures
- Landslide risk communication and management

- Mitigation measures
- Geodetical monitoring
- Concepts, instrumentation, processing
- European case studies (alpine landslides)
- North American case studies (coastal landslides)
- Case studies from developing and emerging countries

### **Intended Learning Outcomes:**

After the course, students are familiar with different types of landslides and are able to classify and describe landslides types and processes on an international approved level. Students will be able to differentiate causes and triggers of a landslide and to analyse different movement and transportation types. They will be able to select the appropriate investigation techniques for monitoring and to apply hazard mapping and zoning techniques. The students will know and understand the principles of risk assessment and management for landslides and other gravitational natural hazards. They will be able to conduct and interpret basic risk analyses and cost-benefit optimization of landslide mitigation measures.

### **Teaching and Learning Methods:**

The course will consist of 3 lectures. The lectures include videos, slide shows and demonstrations of processes. There will be mandatory exercises and optional field days showing various landslide case studies which have been discussed during the lectures.

### **Media:**

Powerpoint presentation, viewgraphs, blackboard, videos, lecture notes, field trip

### **Reading List:**

- TURNER and SCHUSTER: Landslides: Investigation and Mitigation, National Academy Press, 1996
- CENAT: Dealing with natural hazards and risks, module 3 landslides, web-based lectures, Kompetenzzentrum Naturgefahren der Schweiz CENAT, ETH Zürich
- DUNNICLIFF: Geotechnical instrumentation for monitoring field performance, Wiley, 1993
- SCHOFIELD & BREACH: Engineering Surveying, sixth edition, Elsevier, 2007

- BONNARD, FORLATI & SCAVIA: Identification and Mitigation of Large Landslide Risks in Europe  
- Advances in Risk Assessment, European Commission Fifth Framework Programme, IMIRILAND Project, Balkema Publishers, 2004

- ClimChAlp (CLIMATE CHANGE, IMPACTS AND ADAPTATION STRATEGIES IN THE ALPINE SPACE): Slope Monitoring Methods - State of the Art Report, 2008 [http://www.geo.bv.tum.de/images/stories/dokumente/climchalp\\_-\\_work\\_package\\_6\\_report.pdf](http://www.geo.bv.tum.de/images/stories/dokumente/climchalp_-_work_package_6_report.pdf)

**Responsible for Module:**

Kuroschi Thuro (thuro@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geodetic Monitoring of Landslides (Vorlesung, 1 SWS)

Holst C, Raffl L

Landslides - Recognition, Investigation & Mitigation Measures (Vorlesung, 2 SWS)

Krautblatter M, Holst C, Straub D, Kiefer C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU67003: Process analysis, Modelling and Mitigation of Alpine Hazards | Prozessanalyse, Modellierung und Vorbeugung/Schutzmaßnahmen für Alpine Naturgefahren [W-13]**

Version of module description: Gültig ab winterterm 2016/17

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Die Modulprüfung ist eine schriftliche Klausur von 60 Minuten, in welcher die Studierenden nachweisen, dass sie die unterschiedlichen Prozesse, deren räumliche und zeitliche Entwicklung im globalen Umweltwandel, die ökonomische und soziale Dimension sowie verschiedene Strategien zur Prävention, Frühwarnung, Modellierung und Analyse von alpinen Naturgefahren verstanden haben und durch die Beantwortung von Wissens- und Transferfragen präzise aufzeigen/erklären können. Zudem sollen die Studierenden anhand von fallspezifischen Fragestellungen zeigen, dass sie die Ansätze zur Modellierung und Antizipation alpiner Naturgefahren selbständig bewerten können, und für ein bestimmtes Gefahrenszenario effiziente Strategien der Modellierung, Frühwarnung und Schutzmaßnahmen zu unterschiedlichen Stadien des Risikozyklus entwickeln können. Die Klausur eignet sich hier am besten, weil auch synoptische Zusammenhänge aus mehreren Gebieten der alpinen Naturgefahren analysiert, bewertet und eigene Lösungsideen entwickelt werden sollen.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

#### **Content:**

- Konzepte zu Naturgefahr, Risiko und Katastrophe sowie historische Fallbeispiele zur Gefahrenvorhersage
- On- und off site-Effekte durch Naturgefahren
- Die ökonomische und soziale Komponente von alpinen Naturgefahren, die Dimension von alpinen Gefahren am Beispiel Chinas



- Glaziale Gefahren (Prozesse, Modellierung, Warnung, Prävention)
- Schneelawinen (Prozesse, Modellierung, Warnung, Prävention)
- Periglaziale Gefahren (Prozesse, Modellierung, Warnung, Prävention)
- Hangbewegungen (Prozesse, Modellierung, Warnung, Prävention)
- Murgänge (Prozesse, Modellierung, Warnung, Prävention)
- Überflutungen (Prozesse, Modellierung, Warnung, Prävention)
- Waldbrände (Prozesse, Modellierung, Warnung, Prävention)
- Generelle Konzepte der Warnung, Modellierung und Frühwarnung
- Globaler Wandel in Gebirgsregionen
- Nachhaltige Gefahren- und Risikostrategien für alpine Regionen

### **Intended Learning Outcomes:**

- Nach dem Absolvieren des Moduls sind die Studierenden in der Lage, wissenschaftliche und angewandte Strategien für Analyse, Prozessverständnis, Antizipation und Vermeidung von alpinen Gefahren zu verstehen.
- Die Studierenden verstehen die ökonomische und soziale Dimension alpiner Gefahren.
- Die Studierenden verstehen die Prozesse nivaler, Schwerkraftbedingter, glazialer und periglazialer alpiner Naturgefahren in sich dynamisch verändernden Hochgebirgsregionen.
- Sie erinnern sich an die mechanischen und physikalischen Aspekte der Prozesse sowie stochastische Beschreibungen von Magnitude-Frequenz-Beziehungen und verstehen diese
- Die Studierenden verstehen maßstäbliche Ansätze zur Modellierung und Antizipation ausgewählter gravitationsbedingter, nivaler, glazialer und periglazialer alpiner Naturgefahren.
- Sie sind in der Lage, diese Ansätze unter Berücksichtigung des aktuell beobachteten und vorhergesagten Umweltwandels in alpinen Regionen zu bewerten.
- Die Studierenden verstehen und entwickeln nachhaltige Strategien zur Anpassung und Vermeidung in dynamischen, alpinen Regionen.
- Sie bewerten und entwickeln best-practice-Beispiele aus verschiedenen Gebirgsregionen.
- Die Studierenden sind fähig, realistische Szenarien drohender alpiner Naturgefahren zu entwickeln und das Gefahrenpotential für ausgewählte Einzugsgebiete oder Regionen im Gebirge zu bewerten.
- Sie sind dazu qualifiziert, verschiedene Typen ökonomischer und sozialer Risiken zu analysieren, die durch Multi-Risiko-Szenarien hervorgerufen werden.
- Studierende sind in der Lage, verschiedene Präventions- und Minderungsmaßnahmen zu unterschiedlichen Stadien des Risikozyklus effizient anzuwenden. Dies beinhaltet die Fähigkeit, genannte Maßnahmen bei verschiedenen Gefahren- und Verwundbarkeitsszenarien anzuwenden, um ein dynamisches und flexibles Verständnis von Gefahrenanalyse, -bewertung und -vermeidung zu entwickeln.

Zum Schluss des Kurses werden die TeilnehmerInnen Naturgefahren verstehen, die mit Schwerkraft bedingten, nivalen, glazialen und periglazialen Prozessen in dynamisch sich verändernden Gebirgsregionen verbunden sind. Dies beinhaltet physikalische und mechanische Aspekte des Prozessverständnisses sowie stochastische Beschreibungen von Frequenz-Magnitude-Beziehungen. Studierende werden anhand ausgewählter Beispiele erlernen und verstehen, wie Schwerkraft bedingte, nivale, glaziale, periglaziale, usw. alpine Gefahren modelliert und vorhergesagt werden können. Auf diese Weise können sie best-practice-Beispiele

selbstständig bewerten, um beobachtbare und prognostizierbare Umweltveränderungen und deren Auswirkungen in alpinen Räumen besser einzuschätzen. Die Studierenden werden sich dabei an nachhaltige Anpassungsstrategien in einer sich ständig verändernden Umwelt erinnern.

### **Teaching and Learning Methods:**

Der Kurs besteht aus einer 90-minütigen Vorlesung pro Woche. Mithilfe von aktueller Forschungsliteratur und best-practice-Beispielen werden die Teilnehmer in das grundlegende Wissen, Fallbeispiele sowie Techniken eingeführt. Die Lernergebnisse sind kumulativ, und jedes Kursthema behandelt Prozessverständnis und -wahrnehmung sowie mögliche Minderungsstrategien. Den Studierenden werden grundlegende Daten und aktuelle Referenzen zur Verfügung gestellt, um reelle Szenarien zu untersuchen. Es werden reichlich Videos und Fotos benutzt, um die Studenten in jeden Gefahrenprozess einzuführen, Schutzmaßnahmen/Vermeidungstechniken zu veranschaulichen und mögliche Ergebnisse der einzelnen Techniken darzustellen. Diese Herangehensweise ist notwendig, um die einzelnen Risikoaspekte zu verstehen, die mit Naturgefahren in schlecht zugänglichen alpinen Regionen verbunden sind.

### **Media:**

Power-Point-Präsentation, Videos, Tafelanschrift, Handouts mit den wichtigsten Diagrammen und Tabellen.

### **Reading List:**

6. Caine, N. (1980): The rainfall intensity-duration control of shallow landslides and debris flows. *Geogr. Ann.* 62 A (1-2): 23-27. Krautblatter, M., Dikau, R., 2007. Towards a uniform concept for the comparison and extrapolation of rockwall retreat and rockfall supply. *Geografiska Annaler* 89 A(1), 21-40.
7. Moore, J.R., Gischig, V., Burjanek, J., Loew, S., Fah, D., 2011. Site Effects in Unstable Rock Slopes: Dynamic Behavior of the Randa Instability (Switzerland). *Bull. Seismol. Soc. Amer.* 101(6), 3110-3116.
8. Wieczorek, G. F. & J. B. Snyder (2009): Monitoring slope movements. In: Young, R. & L. Norby (Hrsg.): *Geological Monitoring: Boulder, Colorado*, Geological Society of America, p. 245-271.
9. Willenberg, H., Loew, S., Eberhardt, E., Evans, K.F., Spillmann, T., Heincke, B., Maurer, H., A.G. Green (2008). Internal structure and deformation of an unstable crystalline rock mass above Randa (Switzerland): Part I - Internal structure from integrated geological and geophysical investigations. *Engineering Geology* 101(1-2), 1-14. Krautblatter, M., Verleysdonk, S., Flores-Orozco, A., Kemna, A., 2010. Temperature-calibrated imaging of seasonal changes in permafrost rock walls by quantitative electrical resistivity tomography (Zugspitze, German/Austrian Alps). *Journal of Geophysical Research-Earth Surface* 115, F02003.
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11. Dorren, L. K. A.: A review of rockfall mechanics and modelling approaches, Progress in Physical Geography, 26, 69-87, 2003. Eberhardt, E.: From Cause to Effect: Using Numerical modelling to Understand Rock Slope Instability Mechanisms in: Landslides from Massive Rock Slope Failure, edited by: Evans, S., Mugnozza, G. S., Strom, A., and Hermanns, R. L., NATO Science Series IV: Earth and Environmental Sciences, Springer, Amsterdam, 2006.
12. Smith and D.N. Petley (2009): Environmental hazards – assessing risk and reducing disasters. Routledge, New York.
13. Ortiago, J. and Sayao, A.: Handbook of Slope Stabilisation, Springer, Berlin, 2004.

**Responsible for Module:**

Michael Krautbaltter (m.krautblatter@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Prozessanalyse, Modellierung und Vorbeugung/Schutzmaßnahmen für Alpine Naturgefahren (Vorlesung, 2 SWS)

Krautbaltter M, Rimböck A, Scandroglio R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU68006: Road Safety | Straßenverkehrssicherheit [Road Safety]

#### Road Safety

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>90          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module is graded by a project work (Projektarbeit) including a final presentation.

The project work deals with road safety, selected in agreement with the students and the instructors. Students must clearly define the research question, the scope of the project and the methodology. Students must carry out a critical evaluation of the results.

The project work must include, at least, the following parts: 1. Literature review, 2. Problem definition, 3. Selection and description of the methodology, 4. Analysis of results and 5. Discussion and conclusions. The project work must apply the content of the module and use the appropriate technical language.

The grade consists of the written part of the project work (70%) and a final presentation (30%) of the project work. The recommended number of pages of the written part is 15-25 pages and the recommended duration of the final presentation is 15-20 min. Students have to work in small teams of 3 to 5 members and clearly define their individual contributions. The evaluation of the written part tests the ability of students to formulate problem statements in the area of road safety, to perform a comprehensive literature review of scientific literature, to design, describe and apply scientific methods and to analyze their results. With the presentation and its discussion, students additionally prove their ability to synthesize and communicate complex road safety problems using the appropriate technical language, and to carry out a scientific discussion about their results.

Examples projects of previous years include:

- Identify significant predictors of injury severity in cyclist crashes
- Determination of Severity of Accidents using Statistical Learning Methods
- An analysis of road traffic accidents in different weather conditions.

#### Repeat Examination:

End of Semester

**(Recommended) Prerequisites:**

None

**Content:**

The module covers the following topics:

- Crash causation factors and driver behavior.
- Statistical modelling of crashes.
- Alternative road safety measures.
- Vulnerable road users.
- Safety countermeasures in rural and urban roads.
- Tools for road safety management (Road Safety Inspection and Road Safety Audit).
- Road safety campaigns.
- Economic assessment.
- Connected and automated vehicles.
- Driving assistance systems.

**Intended Learning Outcomes:**

After completion of this module, students are able to:

- Describe road crash causation factors related with driver, vehicle and infrastructure.
- Explain the process and goals for road safety inspections and road safety audits.
- Implement economic assessments of road safety.
- Identify risks and measures for vulnerable road users.
- Identify safety issues at various types of road infrastructure.
- Conduct statistical analysis from road safety databases.
- Predict the road safety level of road facilities based on rigorous statistical techniques.
- Design safety countermeasures to address specific safety problems.

**Teaching and Learning Methods:**

The module consists of two lectures, one on introductory and one on advanced road safety concepts. Both classes are interactive and alternate lecture sessions with exercises (individual) and small projects (not graded, to be completed during the class and presented by small groups of students).

**Media:**

Slides for the presentations used in the class. Datasheets, plans or maps for the exercises and projects.

**Reading List:**

- Simon P. Washington. Statistical and econometric methods for transportation data analysis. CRC Press (2011).
- Hauer, Ezra. Art of Regression Modeling in Road Safety. Springer (2014).
- Additional journal and conference papers will be provided and examined in the class.

**Responsible for Module:**

Moeckel, Rolf; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Fortgeschrittene Straßenverkehrssicherheitskonzepte (Vorlesung, 3 SWS)

Antoniou C [L], Antoniou C, Moghavem Ghaffari S, Al Haddad C, Lu Q

Grundlagen der Verkehrssicherheit (Vorlesung, 3 SWS)

Llorca Garcia C [L], Llorca Garcia C, Moreno Chou A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU68007: Applied Transport Modeling | Angewandte Verkehrsmodellierung [Applied transport modeling]

Version of module description: Gültig ab summerterm 2017

|                       |                             |                                  |                                      |
|-----------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b>  | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3 | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination for the module is in the form of a take-home assignment.

The aim of the exam is to demonstrate that the students understood modeling concepts and methods, and that they can develop a travel demand model, use models to assess the impacts of proposed developments, and describe modeling procedures and results in a documentation. The nature of the exam ensures that students are able to independently use the VISUM software in applying the four-step modeling techniques.

Each student submits an Excel file showing the calculations done on the input data, a Visum version file showing the model output, and a written report detailing the modeling procedures and results.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Transport Planning Models (240744419) by Gebhard Wulfhorst and Chenyi Ji

#### Content:

This module introduces students to the practical application of transport modeling concepts using the VISUM transport modeling software. Topics covered include:

- Conduct of household travel survey and data processing
- Processing of transport network data
- Trip generation modeling

- Trip distribution modeling
- Mode choice modeling
- Traffic assignment modeling
- Scenario management
- Extension of modeling software capabilities with scripts

### **Intended Learning Outcomes:**

Upon completion of the course, students are able to use the VISUM software to model travel demand in order to reconstruct existing traffic conditions in an area and assess the effects of future developments and planned traffic measures. Specifically, they are able to...

- understand modeling concepts and methods
- develop a travel demand model
- use models to assess the impacts of proposed developments
- describe modeling procedures and results in a documentation

### **Teaching and Learning Methods:**

A hands-on computer training approach where students complete real-world tasks with the support of the tutor(s). The tasks mimic the modeling process and subsequent tasks build upon previous tasks such that by the end of the final task, each student would have developed a complete travel demand model from scratch using the VISUM software.

For each task, an introduction is given in the form of a short lecture to help students understand the modeling concepts and methods. After the introductory lecture, students use the VISUM Software and put the theory into practice in order to deepen the knowledge that has been learned during the lectures. Here, the capabilities of the VISUM software for each modeling task are learned.

### **Media:**

- PowerPoint Presentations
- PTV VISUM Transport modeling software
- Microsoft Excel and Access

### **Reading List:**

- Ortúzar, J. de D., and Willumsen, L. G. (2011). Modelling Transport (4th ed.). Chichester: John Wiley & Sons.
- Cambridge Sytematics Inc. (2010). Travel Model Validation and Reasonableness Checking Manual Second Edition.
- PTV AG (2016). PTV VISUM 16 Manual.



**Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Applied Transport Modeling with VISUM (Seminar, 2 SWS)

Ji J [L], Ji J, Pukhova A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU68007: Applied Transport Modeling | Angewandte Verkehrsmodellierung [Applied transport modeling]

Version of module description: Gültig ab summerterm 2017

|                       |                             |                                  |                                      |
|-----------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b>  | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3 | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination for the module is in the form of a take-home assignment.

The aim of the exam is to demonstrate that the students understood modeling concepts and methods, and that they can develop a travel demand model, use models to assess the impacts of proposed developments, and describe modeling procedures and results in a documentation. The nature of the exam ensures that students are able to independently use the VISUM software in applying the four-step modeling techniques.

Each student submits an Excel file showing the calculations done on the input data, a Visum version file showing the model output, and a written report detailing the modeling procedures and results.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Transport Planning Models (240744419) by Gebhard Wulfhorst and Chenyi Ji

#### Content:

This module introduces students to the practical application of transport modeling concepts using the VISUM transport modeling software. Topics covered include:

- Conduct of household travel survey and data processing
- Processing of transport network data
- Trip generation modeling

- Trip distribution modeling
- Mode choice modeling
- Traffic assignment modeling
- Scenario management
- Extension of modeling software capabilities with scripts

### **Intended Learning Outcomes:**

Upon completion of the course, students are able to use the VISUM software to model travel demand in order to reconstruct existing traffic conditions in an area and assess the effects of future developments and planned traffic measures. Specifically, they are able to...

- understand modeling concepts and methods
- develop a travel demand model
- use models to assess the impacts of proposed developments
- describe modeling procedures and results in a documentation

### **Teaching and Learning Methods:**

A hands-on computer training approach where students complete real-world tasks with the support of the tutor(s). The tasks mimic the modeling process and subsequent tasks build upon previous tasks such that by the end of the final task, each student would have developed a complete travel demand model from scratch using the VISUM software.

For each task, an introduction is given in the form of a short lecture to help students understand the modeling concepts and methods. After the introductory lecture, students use the VISUM Software and put the theory into practice in order to deepen the knowledge that has been learned during the lectures. Here, the capabilities of the VISUM software for each modeling task are learned.

### **Media:**

- PowerPoint Presentations
- PTV VISUM Transport modeling software
- Microsoft Excel and Access

### **Reading List:**

- Ortúzar, J. de D., and Willumsen, L. G. (2011). Modelling Transport (4th ed.). Chichester: John Wiley & Sons.
- Cambridge Sytematics Inc. (2010). Travel Model Validation and Reasonableness Checking Manual Second Edition.
- PTV AG (2016). PTV VISUM 16 Manual.

**Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Applied Transport Modeling with VISUM (Seminar, 2 SWS)

Ji J [L], Ji J, Pukhova A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU68009: Applied Transport Planning in Developing Countries | Angewandte Verkehrsplanung in Entwicklungsländern**

Version of module description: Gültig ab winterterm 2017/18

|                       |                     |                          |                       |
|-----------------------|---------------------|--------------------------|-----------------------|
| <b>Module Level:</b>  | <b>Language:</b>    | <b>Duration:</b>         | <b>Frequency:</b>     |
| <b>Credits:*</b><br>3 | <b>Total Hours:</b> | <b>Self-study Hours:</b> | <b>Contact Hours:</b> |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

#### **Content:**

#### **Intended Learning Outcomes:**

#### **Teaching and Learning Methods:**

#### **Media:**

#### **Reading List:**

#### **Responsible for Module:**

Moeckel, Rolf; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU68010: Object-Oriented Programming for Transport Engineers | Objektorientiertes Programmieren für Verkehrsingenieure [Object-Oriented Programming for Transport Engineers]**

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Over the course of the semester, students will submit five exercises (Übungsleistungen). The exercises consist of four take-home assignments (weighting 60% of the overall grade, 15% of each) and a final individual more comprehensive programming task at the end of the module (weighting 40% of the overall grade).

With the four take-home exercises, the students show that they are able to understand the basic programming principles. Assignment sheets will be posted after the introduction of every two chapters and submitted in electronic form during the semester. The assignments include answering theoretical questions, writing small code pieces and correcting errors in provided codes. They will provide the students with feedback on their individual learning progress over the course of this class.

The final exercise serves to assess the capability to use the knowledge in solving real-world problems. The task sheet with transport-related problems will be provided. The students need to design and program their own project by using the object-oriented language Java. This final assignment is designed as a take-home exam as well to provide students with the opportunity to work through the problem at their own pace. With this individual programming project, the students show that they are able to use the achieved knowledge at large.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

None

**Content:**

This module will cover the following topics:

- Language basics
- Methods
- Classes and objects
- Control statements
- Collections
- Input/ Output
- Tests
- git versioning system
- object inheritance
- Exceptions
- Usage of existing frameworks

**Intended Learning Outcomes:**

In this module, students learn to use the programming language Java and how it can be applied to address a variety of transport problems. It will be taught how to design code that builds on the object-oriented paradigm. Students will be able to use a variety of basic programming principles (e.g. control structures, inheritance etc.) to solve real-world problems. After completion of this course, students will be able to write Java programs and to use Java in existing frameworks, e.g. in the transport model MATSim. Over the course of the semester, introductions to collaboration between team members on a software project and version control systems will be given as well. It will be shown how an open-source version control system can be used to improve workflow and collaboration in a programming project.

**Teaching and Learning Methods:**

The module will be taught in lecture sessions with integrated practical exercises. The lectures cover the theoretical concepts by giving presentations and examples. In the practical parts, the students will work on related tasks supervised by a tutor. The tasks will mostly include writing own programs in Java.

**Media:**

- PowerPoint Presentations
- IntelliJ Java integrated development environment (IDE)

**Reading List:**

Sierra K., Bates B., Head First Java, O'Reilly & Associates Inc, Sebastopol, 2005.

**Responsible for Module:**

Moeckel, Rolf; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Object-Oriented Programming for Transport Engineers (Vorlesung mit integrierten Übungen, 4 SWS)



Zhang Q [L], Huang W, Moeckel R, Zhang Q

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU70002: Multimodal and Intermodal Freight Transport | Multimodaler und intermodaler Güterverkehr [Multimodal and intermodal freight transport]**

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The coursework and examination requirements will be based around a structured semester project, in which the students will use suitable modeling tools for the development of a model to predict freight flows at a regional or national scale. A number of tasks will be required for the project execution (data acquisition, assessment and analysis, development of a model, calibration of the model, summarisation of the model outputs). The examination will be conducted with a the submission of a technical report and a personal presentation in which each student will present the semester project work (duration of presentation: 20 min, followed up by 15 minutes of questions and answers). The presentation will be created, presented by and graded for each student individually (even if the project is performed in small groups). Thus, the students demonstrate that they have understood the presented intermodal freight concepts and can independently develop a freight model, including both demand and supply sides, using state-of-the-art software and data.

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

None

#### **Content:**

The content of the module is broken down into two sections, dealing with the fundamental models of freight and logistics, and the main technologies and equipment supporting multimodal and intermodal transport.

Fundamentals of freight and logistics

- Introduction to freight transport and supply chain management
- Freight supply models
- Freight demand models
- City logistics models.

#### Multimodal and intermodal transport

- Loading units and intermodal transport units
- Road, rail and maritime freight transport
- Integrators and air freight
- Container transport and container terminals
- ICT and PCS (Port Community Systems)

#### **Intended Learning Outcomes:**

After completing this module, the participants will be able to estimate the demand for freight transport at the regional and national levels, use common freight demand and supply models, and specify the multimodal and intermodal requirements for serving this demand, including the technological options for each mode.

#### **Teaching and Learning Methods:**

lecture with integrated exercises (presentation slides and whiteboard elaborations), readings, project work, technical visits to multimodal freight facilities;

Lectures and whiteboard demonstrations reveal the importance and function of different building blocks for students. For further clarification real examples of intermodal freight systems will be presented. The project work will combine team work (on the identification of the data sources, and the setup of the models) and individual work (final report and presentation). The project supervision will include predefined fixed milestones, to ensure the smooth progress.

#### **Media:**

Presentation slides, whiteboard, readings

#### **Reading List:**

Suitable research publications will be provided to the class, supplementing the lecture slides and other provided material

#### **Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

#### **Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU70003: Optimisation for Transportation Systems | Optimierung für Verkehrssysteme [Optimisation for Transportation Systems]

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The coursework and examination requirements will be based around a small number of individual problem sets.

The learning outcomes will be examined by exercises. The coursework and examination requirements will be based on 3 to 4 individual problem sets (precise number tba at the beginning of the semester) that will aim at demonstrating that the students have understood the concepts presented in the lectures and are able to formulate simple transportation engineering problems (such as resource allocation, shortest path, flow decomposition) as optimisation problems. Each problem set will be conceptually stand-alone, i.e. will include one or more related questions/problems, aiming at demonstrating that the students have grasped the material. Each problem set will be graded individually and the final grade will be obtained as the weighted average of the individual grades. The weight of each problem set will be indicated on the problem set.

This module is also available to the participants of the TUM Skills Excellence Program. For the participants of this programme there are 20 places available.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Basics in Linear Algebra

#### Content:

The module provides the students with an overview of the tools and methods that are available to solve transportation systems engineering problems as optimisation problems. The following key areas will be covered:

- Formulation and analysis of the problem: definition of decision variables, objective function, constraints
- Optimality conditions: under which conditions can optimality be guaranteed, what are the pitfalls
- Solving equations: Newton's method, quasi-Newton methods
- Unconstrained optimisation: Descent methods and line search, trust region, least squares problems, direct search methods
- Constrained optimisation: simplex method, interior point method
- Network optimisation: definitions (graphs, cuts, paths, trees, networks), the transshipment problem, shortest path, maximum flow
- Discrete optimisation: knapsack problem, traveling salesman problem, branch-and-bound method, heuristics.

### **Intended Learning Outcomes:**

After the completion of the module, the participants will be able to analyze common transportation engineering problems (such as resource allocation, shortest path, flow decomposition), formulate them as optimisation problems, and solve them using available software tools, such as matlab/octave, python or R. The participants will know how to recognise an optimisation problem, and will be able to identify the decision variables, objective function, constraints and solution algorithm.

### **Teaching and Learning Methods:**

lectures (presentation slides and whiteboard elaborations), readings, project work  
Lectures and whiteboard demonstrations reveal the importance and function of different building parts for students. For further clarification real transportation engineering problems will be presented and formulated and solved as optimisation problems. A small number of problem sets will be worked out individually by the students and will be used as the evaluation method for the course.

### **Media:**

Presentation slides, whiteboard, readings

### **Reading List:**

Bierlaire, M., 2015. Optimization: principles and algorithms (No. EPFL-BOOK-211191). EPFL Press.

### **Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Optimization for Transportation Systems (Vorlesung, 4 SWS)

Antoniou C [L], Antoniou C, Lu Q, Sadrani M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU70004: Discrete Choice Methods for Transportation Systems Analysis | Diskrete Wahlmethoden für Verkehrssystemanalyse**

*Discrete Choice Methods for Transportation Systems Analysis*

Version of module description: Gültig ab winterterm 2017/18

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The learning outcomes be examined by excercises (Übungsleistungen).

The coursework and examination requirements will will be based on 3 individual homeworks that will aim at demonstrating that the students have understood the concepts presented in the lectures and are able to specify and evaluate discrete choice models using freely available software (such as pythonbiogeme and R). Each exercise will be conceptually stand-alone, i.e. will include one or more related questions/problems, aiming at demonstrating that the participants have grasped the material. Each homework will be graded individually and the final grade will be obtained as the weighted average of the individual grades. The weight of each homework will be indicated on the assignment.

This module is also available to the participants of the TUM Skills Excellence Program. For the participants of this programme there are 20 places available.

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

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#### **Content:**

The module provides the participants with an overview of the tools and methods that are available to specify and estimate discrete choice models for transportation systems analysis. The following key areas will be covered:

- Mathematical Modeling of Behavior

- Logit and probit models
- Model estimation and specification tests
- Model specification
- Experimental design and data collection
- Mixtures/simulation based estimation
- Latent class and hybrid models
- Panel data and models
- Forecasting and aggregation
- Bayesian procedures

### **Intended Learning Outcomes:**

After the completion of the module, the participants will have established a solid knowledge of the theoretical foundations of choice modelling, and they will be able to specify, estimate and interpret a wide range of discrete choice models, such as logit, probit, nested logit, mixed logit, latent class models. They will be able to obtain revealed-preference and stated-preference data as well as create a suitable experimental design, including the questionnaire. The participants will also be able to use available software tools, such as pythonbiogeme and R to evaluate these models.

### **Teaching and Learning Methods:**

Format: Lecture with integrated practical exercises.

Lectures provide the students with the theoretical basics of Discrete Choice Methods, e.g. the various building parts of the models, related experimental designs and the survey data, as a Powerpoint presentation, supported by pictures, possibly films and discussions. Practical calculation tasks from realistic studies and models provide the quantitative methods for the data analysis and modelling of different Discrete Choice Methods and the calculation and interpretation of the model results.

### **Media:**

Presentation slides, whiteboard, readings

### **Reading List:**

Train, Kenneth E. Discrete choice methods with simulation. Cambridge University Press, 2009.

Ben-Akiva, Moshe E., and Steven R. Lerman. Discrete choice analysis: theory and application to travel demand. Vol. 9. MIT Press, 1985.

Louviere, Jordan J., David A. Hensher, and Joffre D. Swait. Stated choice methods: analysis and applications. Cambridge University Press, 2000.

### **Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Discrete Choice Methods for Transportation Systems Analysis (Vorlesung mit integrierten Übungen, 4 SWS)

Antoniou C [L], Antoniou C, Ma T, Rothfeld R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU70005: Transportation Economics | Transportökonomie [Transportation Economics]

Version of module description: Gültig ab winterterm 2017/18

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination type of the module is a project work.

In the project work, a realistic task from the area of the economic evaluation of transport systems (eg congestion charge, infrastructure investments, sharing concepts) is used to check whether the students are able to evaluate the suitability of the different assessment methods presented in the lecture and choose a suitable one for their project. They also show that they can apply the selected methods correctly to the concrete example, quantify them, and use the results to assess the feasibility and the impact of the project. The participants will do midterm and final presentations, and finally submit a written project work. The final grade will be determined as follows: midterm presentation: 15%, final presentation: 35%, written project work: 50%

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

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#### Content:

The module provides the students with an overview of the tools and methods that are available to evaluate transportation systems from an economic point of view. The following key areas will be covered:

- Introduction to Transport Economics
- Demand and Supply
- Equilibrium
- External Interactions
- Projects appraisal
- Transportation Investments

- Pricing
- Freight Economics
- Sharing Economy

**Intended Learning Outcomes:**

After completion of the module, the students will understand the methodological basis for the economic evaluation of transport systems and infrastructure investments. They are able to evaluate the main economic aspects from the field of transportation systems, transportation measures and investments. Additionally, the students are able to apply core theories of transport economy, such as external cost, marginal social cost, cost/ benefit considerations, demand/ supply interactions and elasticities to practical tasks, evaluate projects and use their calculation results for feasibility recommendations.

**Teaching and Learning Methods:**

Format: Lecture with integrated practical exercises;

Lectures provide the students with the theoretical basics of the economical assessment of transportation systems and projects, e.g. the various building parts of the models, their boundary conditions and application fields, as a Powerpoint presentation, supported by pictures, possibly films and discussions. Practical calculation tasks from realistic studies and models as well as the supervision of a project work provide the quantitative methods for quantitative methods for application and calculation of the methods as well as the interpretation of the model results for their use in feasibility and economic impact considerations for projects.

**Media:**

Presentation slides, whiteboard, readings

**Reading List:**

Small, Kenneth. Urban transportation economics. Vol. 4. Taylor & Francis, 2013.

Button, Kenneth. Transport economics. Edward Elgar Publishing, 2010.

Gómez-Ibáñez, José A., William B. Tye, and Clifford Winston, eds. Essays in transportation economics and policy: a handbook in honor of John R. Meyer. Brookings Institution Press, 2011.

**Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Transportation Economics (Vorlesung mit integrierten Übungen, 4 SWS)

Antoniou C [L], Antoniou C, Ezzati Amini R, Rothfeld R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU70007: Special Topics on Model Calibration | Spezielle Themen zur Modellkalibrierung [Special Topics on Transportation Model Calibration]

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>30   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The expected learning outcome is verified in the form of a project work with an included presentation. The work is composed of 1 integrated project that each student undertakes individually, aimed at assessing the students' achievement of the learning outcomes.

The project is designed to enable the participants, to demonstrate their ability of applying the presented calibration concepts in several stages (15% data analysis and preparation, 10% development of the experimental design, 25% choice and implementation of the calibration algorithm, 15% integration in the simulation platform, 15% execution of the simulations, 20% capture and analysis of the results). This method of evaluation has been chosen based on the nature of the course (working with real data and software, and exploring the applicability of alternative analysis methods to achieve a well-defined goal). A final presentation will provide the opportunity to the students to organize their work, and receive more formal feedback, while the main deliverable will be the final report, which should be between 30 and 50 pages. The final grade will be determined as a weighted average of the presentation and final report in the following way: final presentation 25%, final report 75%.

This module is also available to the participants of the TUM Skills Excellence Program. For the participants of this programme there are 30 places available.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Traffic simulation and optimisation fundamentals are useful, but not strictly required; familiarity with scripting (e.g. in matlab/python) is a plus

### **Content:**

The content of the module aims to provide the participants with an overview of the core calibration and validation principles for transportation systems analysis, as well as a hands-on practical semester-long project that will allow them to apply what they learn to a real-world problem with state-of-the-art software. The following key areas will be covered:

- Development of an overall calibration and validation procedure
- Identification and selection of calibration and validation parameters
- Choice of suitable goodness-of-fit measures
- Data cleaning and quality assessment
- Sensitivity analysis
- Management of massive computational complexity
- Assessment, analysis and exploitation of calibration and validation outputs
- Visualization and systematic presentation of outputs and results

### **Intended Learning Outcomes:**

After the completion of the course, the student will be in a position to perform, assess and evaluate systematic calibration procedures for all types of simulation models. The aims of this course enable the students to:

- identify appropriate calibration and validation procedures for a given transportation systems data set and research question;
- understand the ideas behind the main calibration and validation methods, their purposes, their assumptions and their limitations;
- apply systematic calibration and validation methods using suitable software tools (e.g. interfaces based on matlab or python, as well as transport simulation software), and interpret the results;
- critically evaluate calibration and validation outputs and prepare outputs for use by different types of decision makers (engineers, managers, policy-makers)

### **Teaching and Learning Methods:**

Format: Project

Lectures introduce the students to the concepts of model calibration and validation using slide presentations, supported by whiteboard writing and discussions, and provide an overview of the available quantitative methods. Suitable software is introduced by the lecturers and provided to the students, along with all necessary data, in order to perform the required project work. The software comprises the traffic simulation software sumo, along with a matlab interface and python interfaces linking matlab and sumo. The students need to primarily interact with the software platform primarily through the matlab interface, through which they develop and execute the calibration algorithms. At the end of the project, the participants need to describe the algorithm that they implemented, document the process they followed in applying the experimental setup, summarize the simulation results that they obtained and comment on them (e.g. identify limitations, or aspects they could have improved). The lecturers work with the students during the remaining time, and the students also work individually between lectures. The project work will be completed individually by each participant.

**Media:**

Presentation slides, whiteboard, readings, software and data

**Reading List:**

Daamen, W., Buisson, C., & Hoogendoorn, S. P. (Eds.). (2014). Traffic Simulation and Data: Validation Methods and Applications. CRC Press.

Antoniou, C., J. Barcelo, M. Brackstone, H.B. Celikoglu, B. Ciuffo, V. Punzo, P. Sykes, T. Toledo, P. Vortisch and P. Wagner (2014), Traffic Simulation: Case for Guidelines, (M. Brackstone, V. Punzo, eds), JRC Scientific and Technical Research Report, EUR 26534 EN. Publications Office of the European Union, Luxembourg. ISBN 978-92-79-35578-3.

Antoniou, C., J. Barceló, M. Breen, M. Bullejos, J. Casas, E. Cipriani, B. Ciuffo, T. Djukic, S. Hoogendoorn, V. Marzano, L. Montero, M. Nigro, J. Perarnau, V. Punzo, T. Toledo and H. van Lint (2016). Towards a generic benchmarking platform for OD flows estimation/updating algorithms: design, demonstration and validation. Transportation Research Part C, 66, pp. 79-98.

**Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Special Topics on Model Calibration (Projekt, 2 SWS)

Antoniou C [L], Antoniou C, Rothfeld R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU70008: Urban Transportation Systems: Operations Research and Emerging Mobility Technologies | Urbane Verkehrssysteme: Betriebsforschung und neue Mobilitätstechnologien [Urban Transportation Systems]**

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The examination of the module consists of 2-3 problem sets on operations research and one take-home essay to be written for emerging mobility technologies.

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

Applied probability and statistics (e.g. BGU70009)

#### **Content:**

The module provides students with an overview of the advanced mathematical analytics for modeling operations of urban transportation systems. The module covers the following components:

- Probabilistic modeling (Poisson Processes, Geometric Probability, Perturbation, Crofton's Method)
- Queueing Theory and Its Applications (Birth-and-Death Process)
- Network Optimization Models (Shortest-Path, Maximum Flow, Minimum Cost, Facility Location)
- Linear Programming (Network Simplex Method)

Besides, this module provides its students with an overview of the effects of emerging forms of transportation, such as ride-hailing and Mobility-as-a-Service (MaaS). The literature on behaviour effects and traffic externalities is analysed in detail, and then the elements for the regulation of these technologies are discussed. The following key areas will be covered:

- The concept of sharing economy
- Ride-hailing: effects on travel behaviour and traffic externalities
- Ride-hailing and substitute modes: competition and increased efficiency
- Regulation of ride-hailing: pricing and optimal fleet size.
- Shared fleet optimal deployment and optimal routing.
- Mobility-as-a-service: bundling future transportation modes.
- Shared mobility and vehicle ownership: future scenarios and the role of the regulator.

### **Intended Learning Outcomes:**

After completion of the module, the students will understand the methodological and empirical basis for the analysis of emerging transportation technologies such that ride-hailing, shared ride-hailing and mobility as a service. The students will have established a solid theoretical foundation and knowledge base for modeling of urban transportation and service systems. Therefore, the students are able to:

- understand the mathematics behind urban operation research methods, their assumptions and limitations;
- apply modern techniques to formulate a mathematical operations research model and interpret the results;
- identify the main analytical models (e.g., optimization models) and econometric tools for the analysis of behaviour and traffic effects of such technologies.
- design an economic model for the regulation of ride-hailing and to solve it.
- discuss the latest research on merging transportation modes and identify the main elements that a regulation should have.

### **Teaching and Learning Methods:**

The module consists of lectures with integrated exercises.

Lectures introduce the students to the concepts of probabilistic analysis and modeling, queueing models, graph theory, and linear programming methods for modeling urban transport systems or network-wide optimization.

Besides, integrated practical exercises provide the students with the theoretical basics of the assessment of emerging modes, e.g. the various parts of appropriate optimization and econometric models presented in the literature. A social welfare maximization model for the regulation of ride-hailing will be solved in the lectures by the students with support from the lecturer, and applied to realistic scenarios using empirical values for input variables and attributes. State-of-the-art papers will be presented and discussed.

Along the course, lectures will use slide presentations, supported by whiteboard writing. Student discussion and active participation will be encouraged throughout the lectures. All methods and calculations will be illustrated with practical examples. Exercises will be given to students following each major topic, and the solutions will be presented and explained in the lectures.

The module will be shifted to the winter term, starting with winter semester 2022/23.

### **Media:**

The contents are provided with presentation slides, whiteboard, exercises, readings.

### **Reading List:**

- Circella, G., F. Alemi, K. Tiedeman, S. Handy and P. Mokhtarian (2018). The Adoption of Shared Mobility in California and Its Relationship with Other Components of Travel Behavior Report, National Center for Sustainable Transportation, United States.
- Docherty, I., G. Marsden and J. Anable (2018). The governance of smart mobility. Transportation Research Part A: Policy and Practice 115: 114-125.
- Hall, J. D., C. Palsson and J. Price (2018). Is Uber a substitute or complement for public transit? Journal of Urban Economics 108: 36-50.
- Henao, A. and W. E. Marshall (2018). The impact of ride-hailing on vehicle miles traveled. Transportation <https://doi.org/10.1007/s11116-018-9923-2>.
- Hillier, S. F., Lieberman, J. G. (2001) Introduction to operations research, 7th ed., McGraw-Hill
- Kamargianni, M. and M. Matyas (2017). The Business Ecosystem of Mobility-as-a-Service. 96th Transportation Research Board (TRB) Annual Meeting, 8-12 January 2017, Washington DC.
- Larson, R. and Odoni, A. (1981) Urban Operations Research, Prentice Hall, (available at: [http://web.mit.edu/urban\\_or\\_book/www/book/](http://web.mit.edu/urban_or_book/www/book/))
- Matyas, M. and M. Kamargianni (2018). The potential of mobility as a service bundles as a mobility management tool. Transportation.
- Rader, J. D. (2010) Deterministic Operations Research: Models and Methods in Linear Optimization. John Wiley and Sons
- Shaheen, S. (2018). Shared Mobility: The Potential of Ridehailing and Pooling. Three Revolutions. Island Press, Washington, DC: 55-76.
- Tirachini, A. and A. Gómez-Lobo (2018). Does ride-hailing increase or decrease vehicle kilometers traveled (VKT)? A simulation approach for Santiago de Chile. International Journal of Sustainable Transportation. Forthcoming.

### **Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Emerging Mobility Technologies (Vorlesung mit integrierten Übungen, 2 SWS)

Antoniou C [L], Abuelela M, Lu Q

Urban Operations Research for Transportation Systems (Vorlesung mit integrierten Übungen, 2 SWS)

Antoniou C [L], Antoniou C, Abuelela M, Sadrani M, Lu Q

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV000018: Concrete and Masonry Structures Basic Module | Massivbau Grundmodul

Version of module description: Gültig ab winterterm 2019/20

|                                  |                            |                                  |                                      |
|----------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5            | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The course assessment comprises a 90 minute written examination.

The objective of the written exam is to assess whether the basic principles of reinforced concrete and masonry design, in particular with reference to the composite action of the various construction materials, can be applied to execute the applicable design checks. In the limited time of the exam, the learning outcomes of the module must be demonstrated through problem analysis and execution of a sensible solution.

The examination is divided into two parts. The first part comprises general questions (30 minutes in duration) which will be multiple choice and/or short answer for which the student must formulate the answer in their own words. This part of the exam is closed book and no study aids are permitted so that the students must be able to answer essential understanding questions from the memory. The second part comprises design questions related to the relevant topics of the module (60 minutes in duration), where paper-based documents, drawing utensils and a non-programmable calculator are permitted. The second part of the exam will be done with the help of study aids, as the students will have to rely on common design tools to solve the exam tasks.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The student should have passed at least the following modules, offered by the faculty BGU at the TUM:

- Modul BGU43020T2: Technische Mechanik 1
- Modul BGU43021: Technische Mechanik 2
- Modul BGU32030: Statik 1

**Content:**

Reinforced concrete design (according to DIN EN 1992-1-1):

- Introduction, development
- Fundamentals
- Safety theory
- Ultimate limit state: bending with and without axial force
- Ultimate limit state: members with and without required shear reinforcement
- Tension force consideration
- Serviceability limit state
- Anchorage of longitudinal reinforcement
- Construction

Masonry design:

- Fundamentals
- Design of masonry according to DIN EN 1996

**Intended Learning Outcomes:**

Upon completion of this module, students will be able to:

- Understand the material behaviour of concrete and steel and their composite action in reinforced concrete.
- Analyse the capacity of reinforced concrete members.
- Understand the background and development of safety theory with partial safety factors
- Apply the basic principles for flexure and shear design at the Ultimate Limit State according to DIN EN 1992-1-1
- Apply the basic principles for design checks at the Serviceability Limit State according to DIN EN 1992-1-1
- Understand the basic behaviour of masonry and apply the relevant design criteria according to DIN EN 1996

**Teaching and Learning Methods:**

In this course the fundamental content of teaching is generally imparted in the form of a classical lecture, which is consistently supported by Powerpoint presentations. Detailed aspects or considerations which are important for the overall understanding are stepwise deduced and vividly explained with the help of blackboard presentations. This approach offers students a clearly and easy readable representation of the contents and supports the concentrated listening and therefore also the comprehension of the students, as they are not distracted by taking notes. The teaching content is deepened by regular lecture hall exercises, which are linked to the progress of the main lecture. In the lecture hall exercises lecture notes with gap-filling text are used to practice and deepen the issues of the main lecture with the help of sample calculations. Linking the theoretical main lecture and the practical tutorials provides an optimal implementation of the content of teaching.

In order to enhance the learning process and better prepare for the written exam, seminars and task sheets are available, but their processing is voluntary. To deepen the theoretical knowledge of the course, a one-day excursion is offered.

**Media:**

PowerPoint, lecture notes, blackboard

**Reading List:**

ZILCH, ZEHETMAIER (2010): Bemessung im konstruktiven Betonbau, 2. Auflage, Springer Verlag

SCHNEIDER (2009): Bautabellen für Ingenieure, Werner Verlag

POHL, SCHNEIDER, WORMUTH, OHLER, SCHUBERT: Mauerwerksbau - Baustoffe, Konstruktion, Berechnung, Ausführung, Werner Verlag

**Responsible for Module:**

Oliver Fischer (oliver.fischer@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Massivbau Grundmodul (Vorlesung, 2 SWS)

Fischer O [L], Fischer O ( Faustmann S, Lamatsch S, Oberndorfer T ), Burger H

Massivbau Grundmodul Übung (Übung, 2 SWS)

Fischer O [L], Oberndorfer T ( Faustmann S, Lamatsch S ), Burger H, Lamatsch S, Faustmann S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV000063: System-Theoretical Principles of Project Management | Systemtheoretische Grundlagen des Projektmanagements [GL\_PM]**

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The elaboration of a respective project by a team of students proves not only their understanding of the learning content but also their ability to apply the methods, evaluate the results and consequences and moreover to develop the given approaches for further fields of utilization.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Fundamentals of Process-oriented Planning and Organisation (GPPO BGU 55027)

Higher Mathematics

#### **Content:**

Projects and environment, fundamental definitions, 2nd order management, theory of systems, fundamental mechanisms of coordination, Cross-Impact-Analysis;

Factors of success, function, identification and interactions;

Process-oriented organisation of projects, models of proceeding, organisation structures and complexity;

Cost and resources in complex environments, cost-estimations and separability, expert knowledge, monitoring of cost;

Scheduling duration and target dates, theory of graphs, causal network plans, fuzzy networks, recent developments.

#### **Intended Learning Outcomes:**

Having successfully completed the module the students will have understood the given learning content and will be able to apply and develop this further. Therewith, they know to analyze and evaluate applicable situations and solve respective problems when later professionally working

**Teaching and Learning Methods:**

The learning content is taught via lectures. Supervised exercises and tutorials allow deepening this with the help of examples in interaction with the students.

**Media:**

Lecture notes, power point-presentations, partially use of black/whiteboard, videoclips

**Reading List:**

Detailed lecture notes

**Responsible for Module:**

Dr. Wolfgang Eber (eb@bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Systemtheoretische Grundlagen des Projektmanagements / System-Theoretical Principles of Project Management (Vorlesung, 2 SWS)

Eber W

Systemtheoretische Grundlagen des Projektmanagements / System-Theoretical Principles of Project Management (Vorlesung, 2 SWS)

Eber W [L], Eber W

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV000066: Bidding, Tendering and Billing | Vergaberecht und Vergabeverfahren [VergR]

Version of module description: Gültig ab winterterm 2011/12

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a test (eventually as remote online exam) where the students prove not only their understanding of the learning content but also their ability to apply the methods, evaluate the results and consequences and moreover to develop the given approaches for further fields of utilization. Admissible auxiliary materials will be announced in the lecture. The test requires partly the student's own formulations, partly the qualifiedly checking of predefined statements.

#### Repeat Examination:

#### (Recommended) Prerequisites:

none

#### Content:

Types of invitations to tender; impact of the invitation to tender on the detailed definition of the construction target; methods of cost determination and entrepreneurial calculation; utilization of calculation tools (e.g. SIRADOS); Evaluating of tender calculations, price comparison lists; project based cost controlling; excerpts from the "Vergabehandbuch" (EFB).

#### Intended Learning Outcomes:

Having successfully completed the module the students will have understood the given learning content and will be able to apply and develop this further. Therewith, they know to analyze and evaluate applicable situations and solve respective problems when later professionally working.

**Teaching and Learning Methods:**

The learning content is taught via lectures. Supervised exercises and tutorials allow deepening this with the help of examples in interaction with the students. References to professional practice are maintained also by contributions of guest lecturers.

**Media:**

Lecture notes, power point-presentations, partially use of black/whiteboard, videoclips, excursions

**Reading List:**

Detailed lecture notes

**Responsible for Module:**

Prof. Dr. Konrad Nübel (konrad.nuebel@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

AVA - Ausschreibung, Vergabe, Abrechnung (Tendering, Bidding and Billing) (Vorlesung, 2 SWS)

Nübel K [L], Nübel K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV000082: Financing of Real Estate | Immobilienfinanzierung [ImmoFin]

Version of module description: Gültig ab summerterm 2019

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a test (eventually as remote online exam) where the students prove not only their understanding of the learning content but also their ability to apply the methods, evaluate the results and consequences and moreover to develop the given approaches for further fields of utilization. Auxiliary materials are not admissible. The test requires partly the student's own formulations, partly the qualifiedly checking of predefined statements.

#### Repeat Examination:

#### (Recommended) Prerequisites:

none

#### Content:

Definitions and Basics of Real Estate Finance; Types of Loans; Securing a Loan; Funding; Bond System; Financial Risk; Real Estate Structured Finance; Securitization; Real Estate Investment Trusts

#### Intended Learning Outcomes:

Having successfully completed the module the students will have understood the given learning content and will be able to apply and develop this further. Therewith, they know to analyze and evaluate applicable situations and solve respective problems when later professionally working.

#### Teaching and Learning Methods:

The learning content is taught via lectures. Supervised exercises and tutorials allow deepening this with the help of examples in interaction with the students. References to professional practice are maintained also by contributions of guest lecturers.



**Media:**

Lecture notes, power point-presentations, partially use of black/whiteboard, videoclips

**Reading List:**

Detailed lecture notes

**Responsible for Module:**

Prof. Dr. Bing Zhu (bing.zhu@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Immobilienfinanzierung (Vorlesung, 2 SWS)

Zhu B [L], Zhu B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV000086: Town Planning | Stadtplanung und Stadtentwicklung [StPI&Entw]

Version of module description: Gültig ab summerterm 2019

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of the elaboration of a respective project by a team of students as well as an oral test (30min) where the students prove not only their understanding of the learning content but also their ability to apply the methods, evaluate the results and consequences and moreover to develop the given approaches for further fields of utilization. The results of the test and of the project will be weighted equally.

#### Repeat Examination:

#### (Recommended) Prerequisites:

none

#### Content:

Planning and management of urban development projects and development measures; urban perspectives and challenges; development and promotion (e.g. housing); development of industrial real estate; functions, legislation and instruments of urban planning; procedure of binding land use planning; urban development contracts; law of building regulations; public-private-partnership in city planning; social and fair development of real estate

#### Intended Learning Outcomes:

Having successfully completed the module the students will have understood the given learning content and will be able to apply and develop this further. Therewith, they know to analyze and evaluate applicable situations and solve respective problems when later professionally working.

**Teaching and Learning Methods:**

The learning content is taught via lectures. Supervised exercises and tutorials allow deepening this with the help of examples in interaction with the students. References to professional practice are maintained also by contributions of guest lecturers.

**Media:**

Lecture notes, power point-presentations, partially use of black/whiteboard, videoclips

**Reading List:**

Detailed lecture notes

**Responsible for Module:**

Prof. Dr. Bing Zhu (bing.zhu@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV020001: Continuum Mechanics | Kontinuumsmechanik

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105  | <b>Contact Hours:</b><br>75          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcome is confirmed by passing a 90 minute written examination.

The aim of the examination is the confirmation that the key mechanical concepts (continuum mechanical modelling, description of problems in different coordination systems with tensors, mechanical conservation equation, principles of work and energy) can be concisely recalled, implemented and evaluated. Furthermore, problems must be analyzed and solution approaches found within a limited time using the learning outcomes achieved during the module.

The solutions sometimes require the student's own interpretation, in part selection of single or multiple choice answers whereby the emphasis is on short calculation exercises.

No auxillary means are allowed in the examination with the exception of a formulae collection (provided).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Basic knowledge in differential and integral calculus
- Basic knowledge in statics
- Basic knowledge in mechanics of materials

#### Content:

The thematic outline is as follows:

- Introduction into tensor calculus
- Description of stress states in arbitrary curvilinear coordinates
- Lagrangian description of strain states

- Conservation of energy
- Conservation of mass
- Constitutive relations
- General treatment of continuum mechanical knowledge in order to solve non-linear problems
- References to approaches of Technical Mechanics (Torsion, Bending, Plates, Dynamics)
- Approximate solution methods

### **Intended Learning Outcomes:**

After successful participation in the module Continuum Mechanics the students are able to apply tensor calculus and to evaluate stress and strain states of a given system. The students know how to evaluate the applicability of different coordinate systems as well as to analyze the approaches that have been made during previous modules concerning stress and strain states. Moreover, the students are able to assess the studied energy methods and to transfer them to numerical approximation approaches like the Finite Element Method or the Boundary Element Method.

### **Teaching and Learning Methods:**

The module consists of lectures with integrated exercises and seminars. The topics of the lectures are taught with the help of presentations, illustrated examples, real and abstract models as well as via discussions with the students. Further the lectures should encourage the students to enrich their studies through additional literature. In the scope of the integrated exercises selected examples and concrete problem tasks are handled. Furthermore voluntary exercise sheets are provided with which students have the opportunity to practice with the material. During the seminars, possible solutions of the exercise sheets are presented and discussed. Thus, the students are able to verify their own solutions and thereby deepen their knowledge. Regular consultation hours offer the chance to ask questions.

### **Media:**

- Lecture and tutorial notes with additions during the lectures (Tablet-PC with projector)
- Notes based on the blackboard notes for calculations
- Small models, rubber foam systems and plastic membranes
- Animations
- Exercise sheet will be made available online

### **Reading List:**

Schade, Neemann: Tensoranalysis. de Gruyter, 2009

Mehlhorn: Der Ingenieurbau, Grundwissen, Band Elastizitätstheorie. Ernst & Sohn, 1996

Romano: Continuum Mechanics using Mathematica. Birkhäuser, 2005 ca, Birkhäuser

### **Responsible for Module:**

Prof. Dr.-Ing. Gerhard Müller

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Seminar Kontinuumsmechanik (Seminar, 1 SWS)

Lainer M, Schneider F, Weber F

Kontinuumsmechanik (Vorlesung mit integrierten Übungen, 4 SWS)

Müller G, Lainer M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV030011: Computational Linear Algebra | Computational Linear Algebra

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Learning success will be verified via a 90 minute written examination, in order to show students' familiarity with the discussed topics as well as their ability to apply learned methods and concepts for specific problems from the field of linear algebra. Therefore, short problems have to be solved and questions (concerning the number representation on computers or different properties of matrices and linear solvers, e.g.) have to be answered as text or checkmark. Additional resources that are allowed throughout the examination are printed lecture slides and hand-written notes.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Knowledge of any programming language (for instance C/C++ or Fortran)
- Engineering Math

#### Content:

- Number representation (ones' / two's complement, floating point numbers)
- Foundations of linear algebra (norms, dot-product)
- Matrices (different types, condition number, spectral radius)
- Banach's fixed-point theorem
- Direct solvers (Gauss, Cholesky, QR-Zerlegung)
- Iterative solvers (splitting methods, relaxation, Krylov subspace methods, multigrid methods)
- Preconditioning (scaling and incomplete LU / Cholesky decomposition)

#### Intended Learning Outcomes:

After successful participation students are able to

- understand different number representations and to apply those for encoding and computing with integer and floating point numbers,
- understand the foundations of linear algebra and to apply those using Banach's fixed-point theorem for the convergence analysis of linear solvers,
- know and classify different types of matrices and to analyse their key parameters such as condition number and spectral radius,
- understand different direct solvers and their complexity (regarding runtime and memory) as well as to apply those on own problems,
- understand different iterative solvers and their convergence behaviour as well as to apply those on own problems,
- understand and apply preconditioning techniques and to analyse their effect on linear systems.

### **Teaching and Learning Methods:**

The module is provided as lecture and its contents will be communicated with descriptive and practical examples as well as discussions with students. The lecture should further motivate students to own researches and lecture studies concerning the topics. Exercise sheets (and solutions) that reflect the respective lecture contents will be provided, thus students can use those for their own control when studying and applying the learned methodologies and concepts.

### **Media:**

Main lecture media are PowerPoint slides complemented by the usage of black and white boards. PowerPoint slides are online available for download.

### **Reading List:**

James W. Demmel. Applied Numerical Linear Algebra. SIAM 1997;  
Phillipe G Ciarlet. Introduction to Numerical Linear Algebra and Optimization. Cambridge University Press 1989;  
Gene H. Golub, Charles F. Van Loan. Matrix Computations. The John Hopkins University Press 1996

### **Responsible for Module:**

Alexander Braun (alex.braun@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Computational Linear Algebra (Vorlesung, 2 SWS)

Hug L, Kollmannsberger S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV030012: Engineering Databases | Datenbanken für Ingenieure [EngDB]

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In the 60-minute exam the students have to demonstrate that they understand and are able to repeat the basic working principles of database theory within a limited timeframe. Additionally, they have to identify solutions and their implementations to technical application problems under time pressure accurately.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic programming skills.

#### Content:

This module includes the following topics:

- Conceptual database design
- Relational algebra
- Query language SQL
- Normalization
- Transactions
- Indexing
- Engineering applications

#### Intended Learning Outcomes:

After completion of the module the students are able to:

- create a conceptual database design using the entity-relationship model;
- apply relational database theory;
- use the query language SQL;

- normalize a relational database schema;
- understand indexing structures;
- use databases for engineering applications.

**Teaching and Learning Methods:**

The teaching results of the module are achieved by multiple coordinated components. The lectures are supported by PowerPoint presentations, blackboard scripts and movies illustrating computer simulations. The lecture contents are completed by exercises in the lecture hall.

**Media:**

Moodle e learning platform, presentations

**Reading List:**

Elmasri, R. Navathe, S.B. (2015): Fundamentals of Database Systems. 7th Edition, Pearson.

**Responsible for Module:**

Alex Braun (alex.braun@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Datenbanken für Ingenieure (Vorlesung, 2 SWS)

Abualdenien J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV040005: Nature-oriented Care | Naturnahe Bauweisen

Version of module description: Gültig ab winterterm 2011/12

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Written, closed book exam at the end of the semester (60 min.).

The understanding of the fundamentals as well as the capability to evaluate waterway constructions and river development plans is tested in this exam.

The exam consists of question which have to be answered in written form as well as project plans and images where the students have to develop concepts on their own.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Previous attendance of the module "Applied Hydromechanics" (BGU41018T2) is recommended.

#### Content:

- Basic principles: hydrology; morphology; EU framework directive
- watercourses as an eco-system
- properties and categories of watercourses and their meadows
- types of intervention into natural watercourses and their effects
- river development and fundamentals of river development plans
- ecological waterway construction

#### Intended Learning Outcomes:

On successful completion of this module the students are able to:

- explain the basic concepts of hydrology, morphology and river engineering
- demonstrate features and functions of flowing waters and river meadows
- analyse communities and vegetation in the sphere of rivers
- illustrate fundamentals and basic constructive elements of ecological waterway engineering
- evaluate the effects of different kinds of waterway construction

- predict prospective river development according to different criteria

**Teaching and Learning Methods:**

The lecture is structured as a talk accompanied by slides. There the lecturer connects the theory shown in the slides with his practical work experience. Additionally several example projects will be discussed in class. Therefore students are split into small groups, work on the project and present their results in short talks. By this the students capability to analyse and create river development plans is trained.

**Media:**

slides, lecture handouts, drawings of sample projects

**Reading List:**

H. Patt, P. Jürging, W. Kraus, Naturnaher Wasserbau, Springer, Berlin, 2004

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Naturnahe Bauweisen (Vorlesung, 2 SWS)

Brosda J, Neumeier R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV040053: Computational Fluid Dynamics | Numerische Methoden in der Fluidmechanik (CFD) [CFD]

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module is examined by a written exam and a report (ungraded course achievement).

The 60-minutes exam is without aids. While answering a set of comprehensive questions the students show that they have understood the theoretical concepts of numerical methods to solve partial differential equations and that they are able to differentiate numerical effects in simple situations. In additions the students show that they are able to apply the numerical concepts and methods learned by solving problem covering, discretisation methods, numerical approximation and errors, stability and solutions of the Navier-Stokes equations.

In the report the results of weekly programming exercises, solve by a group of students are documented, which are presented at the end of the semester in a presentation (30 min.). There and in the following discussion and questioning by the lecturer the students show, that they are able to use the correct technical terms and to characterize numerical solvers by their results. Further they show, that they are able, after a discussing with the group members, to decide which method to use for the different types of flow problems.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Prerequisite for this module is the module Fluid Mechanics and Ground Water Hydraulics (BGU41016) or Fluid Mechanics and Transport Mechanisms (BGU41020) or Advanced Fluid Mechanics (BGU41021), respectively. Additional knowledge in Engineering Mathematics including linear algebra, differential calculus, integration, vector calculus and field theory and basic knowledge in programming language Matlab is required.

#### Content:

- basic equations of fluid dynamics

- components of a numerical scheme
- Finite-Difference-Methods
- Numerical approximation
- time integration
- analysis of discretisation methods
- method of weighted residuals
- Finite-Volume-Methods
- solution of the Navier-Stokes equation
- solution of the Poisson equation
- programming of a one-dimensional method to solve the convection diffusion equation using Matlab
- programming a two-dimensional solver for the incompressible Navier-Stokes-equations in Matlab
- analysis of numerical errors

### **Intended Learning Outcomes:**

After successfully passing this course, the students are able to:

- understand the basic components of a numerical method
- develop Finite-Difference and Finite-Volume methods to solve partial differential equations
- work on a problem within a group and to discuss the results of this work using the correct technical terms
- determine numerical errors using Taylor expansion and Fourier analysis
- characterise stability and convergence properties of numerical methods
- evaluate the quality of a numerical simulation
- implement explicit and implicit numerical time integration methods
- implement different solution methods to solve the Navier-Stokes equations for incompressible flows in a flow solver
- select suitable numerical methods for various classes of flow situations

### **Teaching and Learning Methods:**

The teaching content is taught in a lecture and a programming exercise.

In the lecture the basic terms, concepts and methods will be presented using the black board, presentations slides and examples.

In the computer exercise different numerical components of flow solvers will be implemented.

There the students solve programming exercises in groups on their own, being supported by the lecturer if needed. At the end the group work results are demonstrated in short presentations and discussed with the lecturer.

### **Media:**

black/ white board, presentations, notes, script, eLearning, Matlab-code

### **Reading List:**

- lecture script
- J.H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, 3rd Edition, Springer-Verlag, 2002.

- P. Moin, Fundamentals of Engineering Numerical Analysis, Cambridge University Press, 2001

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Computational Fluid Dynamics (CFD) (Vorlesung, 2 SWS)

Manhart M, Sakai Y, Quosdorf D, von Wenczowski S

CFD-Lab / MS III (Übung, 2 SWS)

von Wenczowski S, Sakai Y, Manhart M, Quosdorf D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV070006: Practical Course Analysis and Testing | Praktikum Analytik und Prüftechnik

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Prüfungsleistung besteht aus einer Projektarbeit, in der ein praxisnahes Fallbeispiel im Rahmen der Mikroskopie, der Röntgenbeugungsanalyse, der Thermoanalyse, der chemische Analytik, der Lasergranulometrie und Luftstrahlsiebung, der Bestimmung von Porosität oder der Bestimmung von Oberfläche und Korngrößenverteilung behandelt wird. Das Verständnis über Funktionsweisen, Anwendungsgebiete und Informationsgehalt der behandelten Analysemethoden soll in dieser Projektarbeit, die in Kleinstgruppen (2-3 Studierenden) durchgeführt wird, dargelegt werden.

Die konkreten Aufgabenstellungen werden den Studierenden am Ende Vorlesungszeit bekannt gegeben und müssen innerhalb von 2 Wochen bearbeitet werden. Der schriftliche Bericht muss mindestens 10, darf aber maximal 20 Seiten umfassen.

Die Note ergibt sich für jeden Studierenden der jeweiligen Kleinstgruppe aus dem abgegebenen Bericht, d.h. jeder Studierende innerhalb der jeweiligen Kleinstgruppe erhält die gleiche Note.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Abgeschlossenes Bachelorstudium des Bauwesens (Architektur, Bauingenieurwesen o.ä.), der Ingenieur- oder Naturwissenschaften; Grundlagenausbildung in den Gebieten Mathematik, Physik, Chemie, Werkstoffkunde

#### Content:

Untersuchung von Baustoffen mit folgenden Methoden:

- Mikroskopie
- Röntgenbeugungsanalyse



- Thermoanalyse
- Chemische Analytik
- Lasergranulometrie und Luftstrahlsiebung
- Bestimmung von Porosität
- Bestimmung Oberfläche & Korngrößenverteilung

Darüber hinaus werden praxisnahe Fallbeispiele erst in Kleingruppen von Studierenden bearbeitet und dann gemeinsam mit dem Dozenten besprochen.

### **Intended Learning Outcomes:**

Nach der Teilnahme am Modul sind die Studierenden in der Lage, die Funktionsweise, das Anwendungsgebiet und den Informationsgehalt der behandelten analytischen Methode zu beurteilen und relevanten Vor- und Nachteile zu beschreiben. Durch Praxisbeispiele und die Laborarbeit haben die Studierenden gelernt, wie analytische Methoden im Labor funktionieren und können deren Zeit und Materialaufwand abschätzen. Des Weiteren sind die Studierenden in der Lage die wesentlichen zur Charakterisierung von mineralischen Werkstoffen relevanten analytischen Methoden gezielt im Kontext einer aktuellen Problemstellung mit Bauwerkstoffen zu evaluieren.

### **Teaching and Learning Methods:**

In der Veranstaltung werden die theoretischen Lehrinhalte in Form einer klassischen Vorlesung mit ständiger Unterstützung durch eine PowerPoint-Präsentation vermittelt. Berechnungsbeispiele werden auf Overheadfolien oder an der Tafel unter Einbeziehung der Studierenden durchgeführt. Teilweise werden Anschauungsmaterialien zur besseren Darstellung und zum besseren Verständnis der Sachverhalte verwendet.

Um den Studierenden die besprochenen Analysemethoden zu zeigen, werden in den Laboren direkt im Anschluss zur Lehrveranstaltung Fallbeispiele von den Studierenden in Kleingruppen (2 – 3 Studierenden) weitgehend eigenständig durchgeführt. Die Auswertungen der gewonnenen Versuchs- und Prüfungsergebnisse werden von den Studierenden alleine durchgeführt und anschließend mit dem Dozenten besprochen. Hierbei lernen die Studierenden die neu gewonnenen theoretischen Kenntnisse mit der Praxis zu verbinden sowie die Ergebnisse wissenschaftlich darzustellen und zu interpretieren.

Ein wichtiger Baustein im Rahmen der Projektarbeit ist das Arbeiten im Team. Da jeder Studierende einer Kleinstgruppe gleich bewertet wird, ist ein zielorientiertes und zeiteffizientes Denken, Diskutieren und Ausarbeiten des Berichts für einen erfolgreichen Abschluss des Moduls von großer Bedeutung.

### **Media:**

Skripte, Demonstrationsversuche und eigene Experimente, Power-Point-Präsentationen

### **Reading List:**

Die Studierenden erhalten zu jedem Thema ein Skript. Darin ist eine Auflistung der empfohlenen Literatur für die Themengebiete enthalten

**Responsible for Module:**

Machner, Alisa; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Analytik und Prüftechnik (Übung, 2 SWS)

Machner A [L], Hilbig H, Woydich E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV110005: Seminar Building Physics | Seminar Bauphysik

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                  |
|--------------------------------|----------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Proof of performance is provided by submitting a term paper at the end of the semester, which results in the grade for the module.

The aim of the elaboration is to prove that the topics developed in the course of the seminar have been understood in the context of building physics and can be reproduced in writing. IDuring the course, problems relating to a model space in building physics must be analysed and solutions must be found, implemented and documented based on the learning outcomes acquired in the module.

The production of the homework requires the scientific reproduction of learned processes and methods.

For the production of the seminar work all aids are permitted. Here special emphasis is put on scientifically correct work (in particular using correct references).

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Basic understanding of building physics contexts
- Understanding planning documents
- Constructive understanding of structures and details

Building Physics Basic Module

Building Physics - Supplementary Module

Measurement techniques

#### Content:

Current topics of building physics: heat, moisture, noise, light, sustainability topics change every semester.

- Introduction on specific topics
- Theoretical or practical aspects of these topics
- Software instructions for specialized software if necessary

**Intended Learning Outcomes:**

Small and interdisciplinary teams work on today's topics in building physics. After the course students are able to create parts of planning actions on certain topics of building physics. They are able to evaluate and to analyse similar planning actions.

**Teaching and Learning Methods:**

Lectures and Seminar with presentations. Additional online-course and online-platform.

**Media:**

Powerpoint-presentations and technical literature, specialized software if necessary e.g. thermal simulation, LCA, LCC, etc.

**Reading List:**

Technical publications are made available adapted to the respective topics.

**Responsible for Module:**

Klaus Sedlbauer

**Courses (Type of course, Weekly hours per semester), Instructor:**

Bauphysik Seminar (Seminar, 2 SWS)

Peikos A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV110006: Building Physics in Practice | Bauphysik in der Praxis

Version of module description: Gültig ab winterterm 2018/19

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Exam duration (in min.): 60.

Proof of performance is provided in the form of a written examination. The aim of the written examination is to prove that the topics presented in the course of the lecture can be compiled, have been understood, can be presented in compressed form. Therefore, problems must be analysed in a limited time and solutions must be found. This includes in particular practical building physics questions of energy, including airtightness tests, sound, humidity and lighting. The answers require own formulations, marking multiple choice answers, or own calculations. No tools are allowed except a simple calculator.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Building Physics basic Module
- Building Physics Supplementary Module

#### Content:

Results of recent industry developments concerning building physics tasks and their interpretation.

#### Intended Learning Outcomes:

After participation in the course, students will be able to understand current building physics issues in construction practice. They can analyze problems of building physics especially concerning energy, including air-tightness testing, sound, humidity and lighting.

**Teaching and Learning Methods:**

The course includes lectures and, if necessary, workshops with experiments or the performance of exemplary measurements.

In addition, students are provided with further information on the individual topics in an online learning room.

This enables the guest lecturers to engage an intensive exchange with the students, to answer questions promptly and personally and, if necessary, to carry out the experiments independently.

These questions can then be discussed further in the online learning room and additional information on individual topics can be provided.

**Media:**

- Board, Powerpoint presentations.
- Experiments and workshops if necessary

**Reading List:**

- Kohler, St., et.al.: Energieeffizienz von Gebäuden. Wüstenrot Stiftung, Karl Krämer Verlag Stuttgart + Zürich (2006).
- Gösele, K., Schüle, W., Künzel, H.: Schall, Wärme, Feuchte. Bauverlag Wiesbaden, 10. Auflage (1997).
- von Weizsäcker, E. U., Lovins, A. B., Lovins, L. H.: Faktor vier. Doppelter Wohlstand halbiertes Naturverbrauch. Droemer Knauer, München (1996).
- Bansal, N.K.; Hauser, G. und Minke, G.: Passiv Building Design. A Handbook of Natural Climatic Control. Elsevier Science B.V., Amsterdam, London, New York, Tokyo (1994).
- Hauser, G., Höttinger, K., Stiegel, H. und Otto, F.: Heizenergieeinsparung im Gebäudebestand. Hrsg.: Gesellschaft für Rationelle Energieverwendung (2001).

**Responsible for Module:**

Klaus Sedlbauer

**Courses (Type of course, Weekly hours per semester), Instructor:**

Bauphysik in der Praxis (Vorlesung, 2 SWS)

Nowak S [L], Sedlbauer K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV110050: Sustainability of Buildings | Nachhaltigkeit von Gebäuden

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                  |
|--------------------------------|-----------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination performance is provided in the form of a seminar paper at the end of the semester. The prerequisite for this is an obligatory lecture within the framework of the seminar on the respective topic of the seminar paper. In the paper it should be proven that only with the help of cited sources tasks in the field of sustainability of buildings can be analysed and evaluated and ways to a solution can be found. The subject areas of the seminar papers and the related lectures cover the entire subject matter. This includes in particular the understanding of national and international evaluation methods for sustainable building, associated ecological, economic and social aspects as well as certification procedures. The seminar papers require suitable self-developed structures, own formulations and own content-related solutions to the tasks set.

#### Repeat Examination:

#### (Recommended) Prerequisites:

none

#### Content:

International evaluation methods for sustainable construction including LEED (USA), BREEAM (UK) and DGNB (Germany)

Ecological, economic and social aspects of the sustainability of buildings

Certification processes and criteria of the different systems

#### Intended Learning Outcomes:

After attending the course, students will be able to understand national and international assessment methods and certification procedures (DGNB, LEED, BREEAM and others) for buildings and apply the assessment of individual criteria.

**Teaching and Learning Methods:**

The module is held as a seminar with lectures by the teachers and learners. The teaching of competences and contents is carried out through these lectures. In addition, the interaction between teachers and learners as well as between the learners themselves is given sufficient space in the sense of scientific discussions. The written elaboration (seminar paper) serves to deepen specific questions and also to deepen competences and contents. The essential part of the self-study hours is used for the preparation of the seminar paper.

**Media:**

Powerpoint presentations, eTeaching

**Reading List:**

- Deutsche Gesellschaft für Nachhaltiges Bauen: Das Deutsche Gütesiegel Nachhaltiges Bauen, Aufbau Anwendung - Kriterien; Stuttgart (2009).
- Informationsportal Nachhaltiges Bauen des BMVBS: <http://www.nachhaltigesbauen.de/>
- World Green Building Council: <http://www.worldgbc.org/about-worldgbc/who-we-are>
- U.S.Green Building Council: LEED 2009 for New Construction and Major Renovations; Washington (2008).
- SB Alliance: The SB Alliance. A research based assessment oriented organization; Paris (2008).
- Essig, N.: Die Bemessung der Nachhaltigkeit; in db, Ausgabe 5, S. 62-65; Leinfelden Echterdingen (2009).
- BRE Global: BREEAM Offices 2008 Users Manual; Watford; 2008.
- Larson, N: Rating Systems and SBTool, The International Initiative for a Sustainable Built Environment; Seoul (2007).

**Responsible for Module:**

Klaus Sedlbauer

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV120003: Earthworks and Embankments | Erd- und Dammbau

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written, open book test of 60 minutes duration. All study documents, literature and a simple scientific pocket calculator are permitted as aids.

The examination consists of general theoretical questions and calculations. By means of the general questions, the students demonstrate their ability to describe soil and rock as an earth-building-material, to analyze and classify their structural properties, and to evaluate these in terms of suitability for various construction processes for dams and dikes. On the basis of calculations, the students show that you are able to optimize construction methods as well as transfer soil mechanics knowledge to the construction of earthworks and embankments.

#### Repeat Examination:

#### (Recommended) Prerequisites:

The following modules should be passed: (Notice: The contents of the modules can be found in the respective module manuals (handbooks).)

- Foundation Engineering and Soil Mechanics Base & Supplementary Module (BV000019 and BV500006)
- Technical Mechanics I (BV000001)
- Technical Mechanics II (BV000004)
- Advanced Mathematics I (MA9517)
- Advanced Mathematics II (MA9512)

#### Content:

- Earthworks construction materials
- Construction operations
- Soil compaction

- Soil improvement and soil stabilization
- Cuttings and dams
- Backfillings
- Drainage layers
- Quality assurance

### **Intended Learning Outcomes:**

After participating in the module the student is able to

- describe soil and rock as an earthworks construction material
- classify soil and rock as an earthworks construction material for tenderings
- classify soil and rock for structural purposes
- describe the fundamental relationships of the construction of earth and embankment structures
- analyze the introduced manufacturing processes
- check and critique construction methods
- create quality management processes
- transfer soil mechanical knowledge into earth and embankment construction

### **Teaching and Learning Methods:**

The lecture is intensively assisted by a PowerPoint presentation, whereby the students can directly profit from the experience of the lecturer. The PowerPoint-Slides are prepared for the students and are provided as print-outs in the lecture, as well as in digital form via the e-learning platform Moodle for follow-up purposes.

### **Media:**

lecture notes, Powerpoint-presentation, blackboard, films

### **Reading List:**

HEYER, lecture notes "Erd- und Dammbau"

VOGT, N. lecture notes "Studienunterlagen Grundbau und Bodenmechanik"

KOLYMBAS, D. (1998): Geotechnik - Bodenmechanik und Grundbau; Springer-Verlag (Univ. Innsbruck)

LANG, HUDER, AMANN (2003): Bodenmechanik und Grundbau, Springer Verlag (ETH Zürich)

SCHMIDT, H.-H. (2001): Grundlagen der Geotechnik Verlag Teubner

### **Responsible for Module:**

Akad. Dir. Dr.-Ing. Dirk Heyer, [dirk.heyer@tum.de](mailto:dirk.heyer@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Erd- und Dammbau (Vorlesung, 2 SWS)

Heyer D, Bock B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV120008: Soil Mechanics Lab | Bodenmechanisches Praktikum

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written, closed book exam of 60 minutes duration. Auxiliaries are not allowed.

Through theoretical questions the students prove that they are able to name the main parameters in soil mechanics, explain the theoretical background of soil mechanics experiments and describe the performance and evaluation of those experiments. The questions require mainly descriptive answers in form of bullet points. Sometimes smaller calculations are required.

#### Repeat Examination:

#### (Recommended) Prerequisites:

The following modules should be passed: (Notice: The contents of the modules can be found in the respective module manuals (handbooks).)

- Foundation Engineering and Soil Mechanics Base & Supplementary Module (BV000019 and BV500006)
- Technical Mechanics I (BV000001)
- Technical Mechanics II (BV000004)
- Advanced Mathematics I (MA9517)
- Advanced Mathematics II (MA9512)

#### Content:

- Field tests
- Determination of soil density in the lab
- Proctor test
- Water permeability test
- Compression test

- Shear Box test
- Triaxial test

**Intended Learning Outcomes:**

Upon successful completion of the module, students are able to

- know the main parameters of soil mechanics
- understand the theoretical background to soil mechanics experiments
- describe and carry out experiments
- evaluate experimental results

**Teaching and Learning Methods:**

The shown tests take part in the laboratory of the "Zentrum Geotechnik" in 81245 Munich-Pasing and are practically oriented. After a short theoretical introduction with the aid of a PowerPoint presentation for each test, whereby the students can directly profit from the experience of the lecturer, the students conduct the experiments in small groups independently in the lab. Thereby the results are noted into form sheets, which are then handed out to all of the students for voluntary evaluation.

**Media:**

lab equipment, lecture notes, Powerpoint-presentation

**Reading List:**

VOGT, N. lecture notes "Studienunterlagen Grundbau und Bodenmechanik"

KOLYMBAS, D. (1998): Geotechnik - Bodenmechanik und Grundbau; Springer-Verlag (Univ. Innsbruck)

LANG, HUDER, AMANN (2003): Bodenmechanik und Grundbau, Springer Verlag (ETH Zürich)

SCHMIDT, H.-H. (2001): Grundlagen der Geotechnik Verlag Teubner

**Responsible for Module:**

Sven Manthey M.Sc., s.manthey@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Bodenmechanische Laborübung (Übung, 2 SWS)

Uday A, Zeni M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV120062: Advanced Geotechnics III | Geotechnik Vertiefung III

Version of module description: Gültig ab summerterm 2017

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>4          | <b>Total Hours:</b><br>120 | <b>Self-study Hours:</b><br>75   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Proof of performance takes place in the form of a 60 minute written exam.

The exam consists of basic comprehension questions with unrestricted formulations, as well as calculations and dimensioning questions. It will be extensively proven, that the students have developed an understanding for the conveyed fundamental relationships and also capable of analyzing and solving calculation questions in a limited amount of time. These include:

- knowledge of specialized underground engineering processes and associated verification methods
- calculation of excavation pit closure structures
- calculation of pile foundations

The answers should be in part formulated in a short catchword way, but also require extensive calculations.

In addition to this module examination, the course offers a voluntary mid-term assignment. If the mid-term assignment is passed, the calculated module grade will be improved by 0.3 if, based on the overall impression, the improved grade better reflects the student's proficiency level and the modification of the grade is not decisive for whether or not the examination is passed. The mid-term assignment can be repeated as often as desired.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

The following modules should be passed: (Notice: The contents of the modules can be found in the respective module manuals (handbooks).)

- Foundation Engineering and Soil Mechanics Base & Supplementary Module (BV000019 and BV500006)
- Technical Mechanics I (BV000001)
- Technical Mechanics II (BV000004)

- Advanced Mathematics I (MA9517)
- Advanced Mathematics II (MA9512)

**Content:**

Special Underground Construction:

- earth pressure assumptions
- excavation pit closures
- anchors
- slurry trench walls
- injections
- underpinnings
- jet grouting
- piles
- kinematic element method
- measurement techniques, observation method

**Intended Learning Outcomes:**

After participating in the module events the student is able to

- name subsoil improvement methods
- carry out proving methods for deep pile foundations
- use appropriate earth pressure assumptions for excavation pit closures
- evaluate the stability of slopes
- recognize and calculate the necessity of anchors
- test and judge slurry trench wall constructions
- design injection, underpinning and jet grouting measures

**Teaching and Learning Methods:**

The lecture is intensively assisted by a PowerPoint presentation, whereby the students can directly profit from the experience of the lecturer. In part, demonstration materials for a better illustration of the lecture facts will be handed out. Films concerning experiments and procedures are integrated. The contents of the lecture are deepened by exercise courses. During the exercises lecture notes to be completed by the students are used to deepen the topics of the lecture with calculation examples.

**Media:**

lecture notes, Powerpoint-presentation, blackboard, films, field trips

**Reading List:**

VOGT, N. lecture notes "Studienunterlagen Grundbau und Bodenmechanik"

KOLYMBAS, D. (1998): Geotechnik - Bodenmechanik und Grundbau; Springer-Verlag (Univ. Innsbruck)

LANG, HUDER, AMANN (2003): Bodenmechanik und Grundbau, Springer Verlag (ETH Zürich)

SCHMIDT, H.-H. (2001): Grundlagen der Geotechnik Verlag Teubner

**Responsible for Module:**

Akad. Dir. Dr.-Ing. Dirk Heyer, [dirk.heyer@tum.de](mailto:dirk.heyer@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Vorlesung 1,5 SWS

Übung 1,5 SWS

Akad. Dir. Dr.-Ing. Dirk Heyer, [dirk.heyer@tum.de](mailto:dirk.heyer@tum.de)

Sven Manthey M.Sc., [s.manthey@tum.de](mailto:s.manthey@tum.de)

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV150050: Environmental Geology / Geochemistry | Umweltgeologie / Geochemie

Version of module description: Gültig ab summerterm 2011

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>75   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Prüfungsdauer (in min.): 60.

schriftliche Prüfung

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Basics of geology; organic and inorganic chemistry

#### Content:

- Formation of elements and chemical composition of the crust and igneous rocks
- Aqueous solubility, weathering and geochemistry of natural waters
- geochemical effects of natural colloids
- acid mine/rock drainage, microbial processes, and remediation
- use of stable and radiogenic isotopes in environmental research
- environmental radioactivity
- origin, transport and biological uptake of toxic organic compounds
- particulates, mineral dusts, air pollutants, greenhouse gases, paleoclimate and carbon storage

#### Intended Learning Outcomes:

At the end of the module students are able

- to remember inorganic and organic natural and anthropogenic pollutants
- to understand the basic principles and processes related to distribution, transport and attenuation of hazardous elements in natural environments
- to design and assess isotope studies in environmental problems
- to evaluate the environmental risk of ores and mining wastes and plan remediation concepts



**Teaching and Learning Methods:**

The module is principally a lecture with power point presentations and black board writing. Important working materials such as figures and tables are accessible on-line. For a better learning outcome instructive demonstration materials (rock samples) are shown and given to the students. Some exercises are presented for homework.

**Media:**

powerpoint presentation; geological hands-on samples for illustration; handouts with important figures and tables

**Reading List:**

EBY GN (2003) Principles of Environmental Geochemistry, Brooks Cole.

SHERWOOD LOLLAR B (2005) Environmental Geochemistry (Treatise on Geochemistry, Vol.9), Elsevier.

LANGMUIR D (1997) Aqueous Environmental Geochemistry, Prentice Hall.

**Responsible for Module:**

Kuroschi Thuro (Thuro@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Environmental Geology / Geochemistry (Vorlesung, 2 SWS)

Gilg H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV170004: River Engineering and Hydromorphology | Flussbau und Hydromorphologie [BUI River]**

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

In a written (closed book) examination, students will prove that they are able to understand and reproduce the basic concepts of river engineering and the hydromorphology in a short time, and can propose solutions to application problems.

Due to the current situation (Covid19), the exam will additionally be offered as an exam via videoconference (moodle+zoom).

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basic knowledge in Hydraulic Engineering and Water Resources Engineering

#### **Content:**

- Alluvial channel flow and sediment transport
- Numerical hydromorphological modeling
- River morphology, river response and river stabilization
- Application of HEC-RAS for 1D flow, sediment transport and morphology change

#### **Intended Learning Outcomes:**

Students will be able to

- understand the complex problems in sediment transport in rivers;
- understand the link between morphologic change and sediment transport; Interaction possibilities through river engineering techniques;
- apply numerical model as an alternative tool in river works development.

**Teaching and Learning Methods:**

The module consists of a lecture and an exercise course. The theoretical framework will be presented in the lecture and illustrated with examples; real and virtual models will be presented and explained in discussions with the students. Furthermore, students are encouraged to study scientific literature in order to enrich the discussion of the issues. In the exercises, selected examples are presented and distinct practical questions are shown. In addition to lectures and exercise sheets and E - tests are part of the module, where the practical application is deepened.

**Media:**

Blackboard explanation and PowerPoint presentation

**Reading List:****Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

River Engineering and Hydromorphology (Vorlesung, 2 SWS)

Bui M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV170009: International Water Rights and Politics | Internationales Wasserrecht [GRAMBOW]

Version of module description: Gültig ab winterterm 2020/21

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam in this module is a final written exam (60 min) in which the students have to answer questions in the field of water rights and regulations in an international context.

The comprehension of the lecture contents is also checked by some transfer questions, which are oriented on the presented exemplary areas of application. With the written examination, students demonstrate that they understand the meaning of water for the global development, have knowledge in water rights and regulations in an international context and are able to use sustainable approaches to solve challenges of worldwide water law.

In addition to the final exam, students have the possibility to hold a mid-term presentation of 10-15 min presenting a topic linked to the course content. The presentation will be assessed in a pass/fail mode according to the content of the presentation and the presentation style. By passing the mid-term presentation, students will be awarded a 0.3 bonus on the grade of the final exam. With the mid-term presentation, students demonstrate that they have analyzed a water policy related problem in detail, can assess and evaluate it against the background of international water policy, and can present their summarized results to their fellow students.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bachelor in Civil Engineering or Environmental Engineering

#### Content:

The world water situation is critical. In a first part this is illustrated by showing examples and discussions of international indicators. This should provide the necessary understanding, how policy and law affect this development of problems;

Part two of the course discusses detailed the principles of solutions, which the world has described in the Agenda 21, the approach of Sustainability and the derived Integrated Water Resource Management (IWRM). The basics of good water governance (law and policy) are worked out by introducing the handling of complex structures and check lists like the ten principles of sustainability. This is spiced by enhanced administrative tools and basics of state philosophy. Part three shows and discusses practical solutions: EU- Water Frame Directive; basics of water law at the example of the German WHG and the Bavarian BayWG, Water Policy and Good Governance in practice and the strategy of implementation. The whole lecture includes a discussion of concrete examples from all over the world, delivered by the teacher and the students.

### **Intended Learning Outcomes:**

After completion of the module students will be able to understand the meaning of water for the global development and the multi-dependent system of world environment. They will also understand the important role and principle of sustainability. They will be able to use the sustainable approach for design and construction including balancing the aspects of economy, ecology and social effects and also the usage of integrality (IWRM) and the approaches of efficiency and sufficiency.

They will know the basic lines of good water policy and good governance understand the challenges and principles of worldwide water law.

### **Teaching and Learning Methods:**

In order to complete the module successfully, the knowledge transfer must take place predominantly by practical examples. These examples are provided through a slide presentation. Where possible, also video clips are presented to make contents more clear.

### **Media:**

PowerPoint Presentation and Script

### **Reading List:**

### **Responsible for Module:**

Yannic Fuchs (yannic.fuchs@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Internationale Wasserpolitik und Recht (Vorlesung, 2 SWS)

Grambow M ( Fuchs Y ), Fuchs Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV170051: Energy Economics and Hydro Power | Energiewirtschaft und Wasserkraftanlagen

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                               |
|--------------------------------|-----------------------------|----------------------------------|-------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>one-time |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30   |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam in this module is a written exam of 60 minutes in which the students have to answer questions in the field of energy topics, both economics and technical aspects in a closed books exam.

The comprehension of the lecture contents is also checked by some transfer questions, which are oriented on the presented exemplary areas of application.

#### Repeat Examination:

#### (Recommended) Prerequisites:

For Master students in Environmental Engineering:

Course only available as part of module "Energy Economics, Hydro Power and Energy Storage" (BGU46023).

Bachelor in Civil Engineering or Environmental Engineering.

#### Content:

Energy mix, power gap, increase of oil price, price fixing, nuclear phase out, grid stability, primary energy reserves, Kyoto protocol, CO2 emission trading, power prices, power trading, security of supply, environmental compatibility: These are the topics dominating the news when it comes to energy economics. How do these issues relate to each other? Which rules do energy economics follow? Conventional power or renewable energies: Contradiction or complement? What about the Interaction between energy economics and legislation, society, media or politics?

Hydro power plays a particular role within energy economics. Therefore the second part of the lecture deals with hydro power, being the most important renewable energy. Questions to be discussed will be: What are the potentials of hydro power? What is hydro power's relevance concerning the power mix? Based on a real example of a hydro power project issues as approval procedure, economics calculation, planning, construction, operation and maintenance strategy will be presented. Also this part of the lecture will demonstrate the numerous interfaces between engineering and other aspects linked to it.

**Intended Learning Outcomes:**

At the end of the module students are able to contribute to discussions with the various stakeholders on energy economics and know the various options of power production and its implications. They get an insight in the complex structure of energy and power supply from upstream to downstream.

**Teaching and Learning Methods:**

The lecture is aimed at providing insight into the various aspects of energy economics and at imparting knowledge to the engineer as a basis for working in an unusual and interesting environment. PowerPoint presentation and blackboard explanation for visualizing the topics. There are also discussions with the students during the lectures so they can get a deeper insight in practical experience with the topics.

**Media:**

PowerPoint presentation and blackboard explanation.

**Reading List:**

**Responsible for Module:**

Yannic Fusch (yannic.fuchs@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV180004: Modelling of Water Quality in Aquatic Systems | Modellierung der Wassergüte in aquatischen Systemen**

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination is a 60-minute written test. The aim of the written test is to verify that the basic approaches for modeling of aquatic systems were understood. These problems must be analyzed and based on learning outcomes acquired in the course of the module, find and implement solutions in limited time.

The answers require partly own formulations, partly graphical visualization. The focus is on short calculation and modeling tasks. For the exam no aids are permitted except for a non-programmable calculator.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basics of aquatic systems as well as in mathematical, physical and chemical knowledge are required.

#### **Content:**

1. INTRODUCTION. Aquatic systems and their types: natural and man-made aquatic systems; water and wastewater treatment units. Common features of aquatic systems. The concept of mathematical modeling of aquatic systems: the general hydrodynamic and mass balance equations.

2. THEORY OF REACTORS. Reactions kinetics - order of reaction. Reactor vessels. Theoretical types of flow: Plug Flow vs. Continuous Stirred Tank Reactors. Hydraulic retention time and the concept of Flow through Curve. Reactors in series. Reactor analysis.



3. SIMPLE APPROACHES FOR MODELING OF BIOGAS PRODUCTION. Using Excel for implementing simple models. Useful tools. First steps in modeling.

4. AQUASIM. General introduction to the software. Application exercise for a river simple system for nitrification and biomass decay. Calibration of model parameters. Critical discussion of measurements and model outputs.

**Intended Learning Outcomes:**

After completion of the module students can describe the approaches for simple models, set-up and analyze mass and energy balances, are able to create simple simulations with own modifications.

**Teaching and Learning Methods:**

.In the lecture theoretical principles are first taught using both presentations and black board. In following exercises with commercial (Excel) or specialized software (AquaSIM), the students apply the lessons learned on similar tasks and thereby internalize the approach. The results are discussed and analyzed afterwards.

**Media:**

Board, beamer, computer

**Reading List:**

Chapra S. C. (2008) Surface Water-Quality Modeling. Waveland Press Inc, Long Grove.

Maniak, U. (1997) Hydrologie und Wasserwirtschaft - Eine Einführung für Ingenieure. Springer Verlag, Heidelberg.

Reichert, P. (1998) AQUASIM 2.0 – User Manual. Swiss Federal Institute for Environmental Science and Technology (EAWAG), Dübendorf.

Wichern, M. (2010): Mathematische Simulation biochemischer Prozesse in der Siedlungswasserwirtschaft, Oldenbourg Industrieverlag, München.

**Responsible for Module:**

Dr.-Ing. Konrad Koch, k.koch@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modelling of aquatic systems (Modellierung aquatischer Systeme) (Vorlesung, 2 SWS)  
Koch K [L], Koch K

Modelling of aquatic systems (Vorlesung, 2 SWS)

Koch K [L], Koch K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV180006: Hydrochemistry | Hydrochemie

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The written exam (60 min) consists of general questions and calculations. With the exam students demonstrate that they understand basics and specific interactions of water and hydrochemistry. theoretical knowledge of hydrochemistry, can analyse redox reactions and corrosion processes and are able to develop treatment concepts for specific water contaminants.

The exam is a mix of open questions requiring own descriptions, multiple choice tests and chemical calculations. The use of a calculator is allowed in the written exam

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge of inorganic and organic chemistry from the 2nd and 3rd semester BSc. environmental engineering are necessary to follow lectures

#### Content:

In the lecture the scope of hydrochemistry, water cycle, chemical thermodynamics and reactions are discussed. Acids and bases, dissolved carbon dioxide and the carbonate equilibria are presented. Precipitation and dissolution, oxidation and reduction reactions are content of the course as well as redox and corrosion processes. Furthermore natural and anthropogenic substances and their influences on the chemical composition of natural waters are shown.

#### Intended Learning Outcomes:

After completion of the module, the students are able to describe the basics and interactions of important water properties and contents. They can apply redox reactions and analyze corrosion processes. They are further able to evaluate geogenic and anthropogenic water contents and to develop specific methods for treatment.

**Teaching and Learning Methods:**

The module consists of a lecture series. Presentations during the lectures provide the theoretical basis on water chemistry. Understanding of chemical calculations will be supported in small exercises based on relevant practical applications.

**Media:**

Beamer, board

**Reading List:**

Stumm, W., Morgan, J.J.: Aquatic Chemistry. John Wiley & Sons, 1996, 3rd ed., ISBN: 0-471-51184-6

Grohmann, A.N., Jekel, M., Grohmann, A., Szewzyk, R., Szewzyk, U.: Wasser. De Gruyter Verlag, 2011, ISBN 978-3-11-021308-9

Reemtsma, T., Jekel, M.: Organic Pollutants in the Water Cycle. Wiley-VCH, Weinheim, ISBN-10: 3-527-31297-8

**Responsible for Module:**

Apl. Prof. Dr. Brigitte Helmreich (b.helmreich@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrochemistry (Vorlesung, 2 SWS)

Helmreich B [L], Helmreich B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV180010: River Water Quality Management | Gewässerschutz

Version of module description: Gültig ab winterterm 2012/13

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>1.5        | <b>Total Hours:</b><br>45  | <b>Self-study Hours:</b><br>30   | <b>Contact Hours:</b><br>15          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

oral examination

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basics of wastewater treatment are necessary for the lecture.

#### Content:

The lecture contents energy budget and balance of matter in rivers, handling with eutrophication, selfpurification capacity of rivers, information about microorganisms in waterbody and sediments of waters, quality criteria, analysis of european and german regulations as well as bathing water regulations and hygienic aspects of water sanitation. The so called Streeter Phelps Model is presented.

#### Intended Learning Outcomes:

Students are able to exhibit deepened knowledge of protection of water.

#### Teaching and Learning Methods:

Vorlesung

#### Media:

Beamer, Tafel

#### Reading List:

**Responsible for Module:**

Brigitte Helmreich (b.helmreich@bv.tu-muenchen.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV180051: Hydrochemistry Lab | Hydrochemie Praktikum

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The expected learning outcome is verified in the form of laboratory assignments. The assignments consists of an oral exam to prepare the experiments (20%) in the form of a survey on the experimental design and operation, the laboratory work which consists of 20 experiments (60%), and a final report about the experiments (20%). By answering questions at the beginning of the experiments, the students show that they are sufficiently prepared for the experiments and. During the experiments, they show that they are able to apply the analytical methods according to the guidelines. The students show through the report that they know and understand laboratory methods for the determination of wastewater and drinking water parameters.

Eine Prüfungswiederholung ist nicht möglich, da die Leistung eine Teilnahme am Praktikum erfordert und die Plätze für das Praktikum beschränkt sind.

An exam retake can not be offered since it would imply another participation at the course with limited participants.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering (BGU38014), Advanced Water Treatment Engineering and Reuse (BGU38010/BGU38024), Hydrochemistry (BV 180006)

#### Content:

During the course the determination of the relevant analytical parameters of wastewater is learned by the students: COD, BOD, TOC, nitrate, ammonium. Furthermore the settleability of sludge as well as the sludge volume index are analysed by the students. Phosphate is identified. Respiration measurement of activated sludge as well as batch tests for nitrification are done by the students. Determination of relevant parameters for drinking water quality are a big part of the course: pH value, conductivity, marble dissolution test, water hardness, sodium and potassium

by atomabsorption spectrometry, chloride and sulfate by ion chromatography and kinetic iron oxidation.

**Intended Learning Outcomes:**

Upon successful completion of this course, students are able to determine and discuss water parameters in the laboratory, which are relevant for the design of wastewater treatment plants and waterworks. In addition, they can perform batch tests to assess the nitrification activity in activated sludge.

**Teaching and Learning Methods:**

The module consists of one exercise. During six experimental (full) days in the laboratory exercise students learn to analyze different parameters and perform various tests. In order to learn and practice the processes in the laboratory, the students prepare themselves reading the course manual and then work in the laboratory in teams of 2 students under the guidance of a supervisor. Results from analyzed parameters will be discussed in small groups of 6 students with the tutor.

**Media:**

Experiments in the laboratory

**Reading List:**

Manual „Hydrochemistry Laboratory“

**Responsible for Module:**

Apl. Prof. Dr. Brigitte Helmreich (b.helmreich@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrochemistry laboratory (Übung, 4 SWS)

Knoop O [L], Helmreich B, Hübner U, Knoop O, Petz S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV180071: Fundamentals of Urban Climate | Urban Climate - Grundlagen

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>135  | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The oral exam (30 min) consists of a group presentation followed by an individual interview each contributing to 50% of the final grade. By presenting their results from group exercises, students demonstrate their scientific understanding of interactions between climate and city and their ability to implement urban planning projects. In the individual interview, fundamental understanding of urban climate is tested.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basics of Meteorology

#### Content:

Urban climate investigations are a major tool for a sustainable urban development. Ventilation conditions, heat islands and air pollution aspects have a great influence on human health and well-being. In the same time, air pollution is affected by meteorological parameters.

The focus of this module lies on both, the thermal aspects and air pollutions problems. Lectures include an introduction to urban climatology and how to use results for planning. The link between urban planners, architects and urban climatologists is described and the planning level defined. Practical information is given how urban climatic maps are prepared and how they can be used for planning. Meteorological measurements and calculations will be carried out, presented and evaluated. In addition, an introduction to numerical urban climate modeling is given and evaluated by own practical field investigations.



**Intended Learning Outcomes:**

After successful completion of the module students will be able to analyze the basics of urban climate and design and conduct meteorological measurements for urban planning projects. Furthermore they can evaluate data from case studies and numerical modelling to assess effects from measure to improve ventilation conditions and reduce air pollution.

**Teaching and Learning Methods:**

The module will be held as a 5-day block course. Lectures in the morning will provide theoretical background of urban climate. In the afternoons, students will work in groups on case studies either using models or measurements. Activities will result in the design of urban climate maps or detailed analyses of air pollution and urban climate /microclimate.

**Media:**

Beamer

**Reading List:**

Kuttler, W. 2010. Klimatologie, UTB, Ulmer Verlag, Stuttgart  
Ren, C., Ng, E., & Katzschner, L. 2011. Urban climatic map studies: a review. International Journal of Climatology, 31 (15): 2213-2233. DOI: 10.1002/joc.2237  
Erell E., Pearlmutter D. and Williamson T. 2010. Urban climate: Designing Spaces Between Buildings, earthscan/James & James Science Publishers, London  
Lehmann, St 2015. Low Carbon Cities, earthscan series sustainable design, routledge, London, p. 331 - 349  
Ng, E.2010. Designing High-Density Cities, earthscan, London  
Ng, E., Chao, R., Ed. 2015.The Urban Climatic Map for sustainable development, earthscan, routledge. London  
Oke, T.R., Mills, G., Christen, A., Voogt, J.A. 2017. Urban Climates, Cambridge University Press  
Lenzholzer, S. 2015. Weather in the city, nai010 publishers

**Responsible for Module:**

Uwe Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**

Lutz Katzschner

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV210013: Urban und Regional Planning | Stadt- und Regionalplanung

Version of module description: Gültig ab summerterm 2017

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The 10-page report should have 4 sections. Each section must be related to one of the themes discussed in the class. The student must demonstrate with each section that they have gained knowledge of the reading material and discussions surrounding a particular topic in urban and regional planning. They must show that they are able to discuss different theoretical and case-based perspectives on urban and regional planning, and that they are able to reflect upon their own learning and position in these debates. The report must present the student's acquired knowledge on urban and regional planning in a structured way, and demonstrate their ability to analyse cases of urban and regional planning. Overall, the report should demonstrate that the student has understood essential aspects of urban and regional planning in theory and practice, and is able to present this knowledge in writing.

The written report will be complemented by a short 10-minute presentation (20%), through which the student will demonstrate their ability to communicate scholarly work to an audience, by presenting their main academic reflections on urban and regional planning to the class.

The final grade is a summation of grade from the report (80%) and the presentation (20%).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

The aim of this course is to introduce students to key themes and debates in urban and regional planning. The course takes a generally critical and reflective approach, asking 'why' urban and regional planning is practised in certain ways, and encouraging critical discussion of contemporary planning cases. The course briefly introduces urban and regional planning, discussing the origins

and aims of planning, and developments in planning theory. The initial sessions will introduce questions about the changing roles of plans, form, processes and people in urban and regional planning, and the different perspectives these focus areas provide on the city. After this section of the course, the focus turns to a number of contemporary topics, which will be presented and discussed with case studies of different cities from around the world. These sessions will address questions such as the aims of planning and planning processes in different contexts, the role of identity in planning, and technology and planning. The cases used for discussion in the course will be drawn from an international research literature.

### **Intended Learning Outcomes:**

Upon successful completion of this course, students are able to:

- Understand the foundation(s) and differing aims of urban and regional planning
- Explain key perspectives in urban and regional planning
- Apply key theories to case studies of urban and regional planning
- Analyse cases of urban and regional planning
- Critically discuss international literature on urban and regional planning
- Communicate knowledge about urban and regional planning orally and in text.
- Critically reflect on current developments and trends in urban and regional planning
- Reflect upon their own position in debates on urban and regional planning.

### **Teaching and Learning Methods:**

The course is based around weekly interactive seminars, during which literature and case studies from urban and regional planning practice will be discussed. The lecturer will facilitate discussion between students through questions and group work, and short PowerPoint presentations with key points. Students are required to read and prepare for all the sessions, and to take an active part in class discussions. If for whatever reason you are not able to read and prepare for the sessions and actively participate in the seminars, signing up for this class is not recommended!

### **Media:**

Various reading materials, including books, scientific articles, planning documents and websites. PowerPoint, whiteboard and exercise sheets may be used in sessions.

### **Reading List:**

### **Responsible for Module:**

Wulforst, Gebhard; Prof. Dr.-Ing.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Stadt- und Regionalplanung (Seminar, 2 SWS)

Nichols A, Haxhija S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV320006: Modelling in structural analysis | Modellbildung in der Baustatik [MB]

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The grading is done by a project work. The extent of the project work is about ten to 20 pages including post-processing prints of the program and hand calculations for checking the results. The topic of this work is the calculation of a complex static system, which is close to real world structures, using the software presented during the module. The students should show that they can apply the different element formulations. Furthermore, an understanding of the influences of modellings issues on the structural model is to be revealed. By a short talk, when handing in the project work, students should show the ability to judge about numerical results and present them in a comprehensive way to a possible customer.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basic education, e.g. by a bachelor's degree in civil engineering. It is recommended to visit a module about the basics of the finite element method (BGU32028 Introduction to Finite Element Methods) before.

#### Content:

The main content of the module are the basic methods to model structures in civil engineering by finite elements. Therefore, the following aspects come into play:

- Application of the finite element method with different element formulations.
- Coupling of different types of finite elements.
- Recognizing the main influences of modelling aspects on the structural model.

Evaluation of the numerical results.

**Intended Learning Outcomes:**

After participating in this module, the students are able to apply the finite element software presented during the module for comprehensive modelling of civil engineering structures. Furthermore, they should be capable of assessing modelling influences on the static system and they should be able to interpret the results of their calculations.

**Teaching and Learning Methods:**

Computer exercise with notes on the blackboard and overhead projections. Different examples are solved by a commercial finite element software. This is done partially self-contained and partially by instruction.

**Media:**

Presentation supported by media (PowerPoint, videos, etc.), notes on the blackboard, preprints and a commercial finite element software.

**Reading List:**

Werkle, H., Finite Elemente in der Baustatik

**Responsible for Module:**

Prof. Dr. -Ing. Kai-Uwe Bletzinger (kub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modellbildung in der Baustatik (Vorlesung, 2 SWS)

Bletzinger K [L], Bletzinger K ( Fußeder M, Goldbach A, Sautter K, Singer V )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV340001: Rail Design | Rail Design

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The written examination with a duration of 60min consists of 3 to 5 calculation tasks related to rail specific problems. In the examination students demonstrate the knowledge of rail superstructure loading and models used for safety analysis and design procedures. With helping material the ability is tested to analyse the behaviour of rail superstructure and to create solutions based on the modelling tools and knowledge taught by the module.

Accepted helping materials are lecture notes and a calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Kinematics and dynamics of driving BV 340007,  
Construction of Traffic Infrastructure BV 340008,  
Infrastructure design BV 340009

#### Content:

Rail traffic and temperature loading, modelling procedures and tools for analysis and design of rail superstructure, Track stability, constructive features and design of ballastless track systems, Design and testing of substructures and components, Tracks for urban rail transport, green tracks, noise and vibration mitigation, maintenance management

#### Intended Learning Outcomes:

After completion of the module, students are able to understand the behaviour of rail superstructure loaded by rail traffic and additional loading (temperature), to apply procedures and modelling tools for superstructure design and to analyse constructive features. Students are able to create proposals for structural improvement of rail superstructure.

**Teaching and Learning Methods:**

The module is based on conventional lectures supported by Powerpointpresentation. Demonstration materials are used to support the description of topics, videos are part of the presentation. The content of the lecture is practised by exercises during the lectures. An excursion takes place to study the practical transfer and implementation of lecture content.

**Media:**

Lecture notes, handouts, Powerpoint-presentation, board-work, videos, excursion

**Reading List:****Responsible for Module:**

Stephan Freudenstein (stephan.freudenstein@tum.de) Bernhard Lechner  
(bernhard.lechner@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV340002: Road Design | Road Design

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The written examination consists (60 min) of several calculation tasks related to concrete and asphalt pavement specific problems. In the examination students demonstrate the knowledge of pavement loading and models used for analysis and design procedures. The ability is tested to analyse the behaviour of road superstructure and to create solutions based on the modelling tools and knowledge taught by the module. The number of tasks is 3 to 5.

Accepted helping materials are lecture notes and a calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Kinematics and dynamics of driving BV 340007,  
Construction of Traffic Infrastructure BV 340008,  
Infrastructure design BV 340009

#### Content:

Pavement loading, modelling procedures and tools for analysis and design of asphalt and concrete pavements, Environmental impacts, constructive features and design of road superstructure, noise mitigation, maintenance management

#### Intended Learning Outcomes:

After completion of the module, students are able to understand the behaviour of road superstructure loaded by road traffic and additional loading (temperature), to apply procedures and modelling tools for asphalt or concrete pavement superstructure design (plain concrete and reinforced concrete pavements) and to analyse constructive features. Students are able to create proposals for structural improvement of pavements used by conventional road traffic or by special loading e.g. airside pavements or container terminals.

**Teaching and Learning Methods:**

The module is based on conventional lectures supported by Powerpointpresentation. Demonstration materials are used to support the description of topics, videos are part of the presentation. The content of the lecture is practised by exercises during the lectures

**Media:**

script, powerpoint-presentations, board-work, videos

**Reading List:**

**Responsible for Module:**

Stephan Freudenstein (stephan.freudenstein@tum.de) Bernhard Lechner  
(bernhard.lechner@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Road Design (Vorlesung mit integrierten Übungen, 3 SWS)

Lechner B [L], Lechner B, Simon C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV340008: Construction of Traffic Infrastructure | Bau von Verkehrsinfrastruktur

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Current information in view of the limited presence due to the CoViD19 pandemic: If the general conditions (hygienic rules, distance rules, etc.) for a presence check are not available, the planned form of examination can be changed to [specify the alternatively planned form of examination or the electronic (remote) examination] according to §13a APSO. The decision on this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the responsible examination committee.

The examination should be a written examination (Closed Book).

In the ca. 60 min. long written examination students demonstrate by answering questions under time pressure and without helping material the understanding of the materials, material properties, components und sub-system behaviour and procedures applied for construction and maintenance of road and rail infrastructure.

The ability is tested to evaluate the standards used for infrastructure construction and maintenance.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

- Cross-section design of roads
- Cross-section design of railway tracks:
- Substructure, Earthworks
- Frost protection,

- Drainage
- Base layers:
- Asphalt pavements
- Concrete pavements:
- Conventional and improved ballasted tracks
- Ballastless tracks
- Special pavements
- Traffic infrastructure maintenance

**Intended Learning Outcomes:**

Upon completion of the module students are able to understand the materials, material properties, sub-system and component behaviour as well as requirements for transportation infrastructure design and construction. The students are able to evaluate tools and standards used for road and rail construction and maintenance.

**Teaching and Learning Methods:**

Classic lecture with Powerpoint presentation and blackboard descriptions. Sometimes visual aids are used and passed. Films are integrated into the presentations. The subject material can be deepened by examples in class. In addition there are study trips to construction sites.

**Media:**

Script, Powerpoint presentations, blackboard, study trips

**Reading List:**

Script

Lechner, B.: Kinematics and Dynamics of Driving

**Responsible for Module:**

Stephan Freudenstein (stephan.freudenstein@vwb.bv.tum.de) Bernhard Lechner  
(bernhard.lechner@vwb.bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Construction of Traffic Infrastructure (Vorlesung, 3 SWS)

Lechner B [L], Lechner B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV340021: Air Transport and Airports | Luftverkehr und Luftverkehrsanlagen

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Current information in view of the limited presence due to the CoViD19 pandemic: If the general conditions (hygienic rules, distance rules, etc.) for a presence check are not available, the planned form of examination can be changed to [specify the alternatively planned form of examination or the electronic (remote) examination] according to §13a APSO. The decision on this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the responsible examination committee.

The examination should be a written examination (Closed Book).

In the written examination students demonstrate by answering questions under time pressure and without helping material the understanding of the flight physics, legal regulations and requirements for air transport and their integration into airport design.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

- Aircraft characteristics (technical and operational aspects) and development
- Physical behaviour of an aircraft (nomenclature, coordinate systems, equations of motion, state space model and modelling, external forces)
- Flight dynamics at the flight phases takeoff and landing
- Introduction to the flight operations (cockpit instruments / layout, radio beacons, instrument landing system ILS, multi-crew concept, weather, weight and balance)

- Aircraft and propulsion system,
- Airport operation, airline operation, air traffic control, safety and airworthiness in air traffic,
- Legal aspects of air transport
- Layouts and dimensions for international airports; General installations; Layout and configuration of terminal buildings, aprons, taxiways and runways;
- Aircraft loads and design features for airside pavements; Aircraft and Pavement Classification ACN-PCN.

**Intended Learning Outcomes:**

Studying flight operation and its resulting impact on airport design. The students are able to understand the requirements at airports resulting from the flight dynamics of an aircraft system. Students are able to apply the discussed methods of dimensioning and design of airfields and analyze and evaluate airfield constructions.

**Teaching and Learning Methods:**

Classic lecture with Powerpoint presentation and blackboard descriptions. Films are integrated into the presentations. The subject material can be deepened by examples in class. The students perform an approach and/or take off at an airport in a research simulator.

**Media:**

Lecture notes, power point presentation, whiteboard, research flight simulator

**Reading List:**

**Responsible for Module:**

Stephan Freudenstein (stephan.freudenstein@vwb.bv.tum.de) Bernhard Lechner (bernhard.lechner@vwb.bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Air Transport and Airports (Vorlesung, 3 SWS)

Lechner B [L], Lechner B, Plötner K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV360006: Acoustics incl. Acoustics Laboratory Practice | Akustik inkl. Akustisches Laborpraktikum**

Version of module description: Gültig ab winterterm 2019/20

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The aim of the written examination (60. min.) is to prove that the essential building acoustics and room acoustics phenomena have been understood, can be condensed and applied, in particular sound generation, propagation and perception as well as the associated mathematical basics, e. g. wave equation or calculation with sound levels. In order to do this, problems must be detected and solved in a limited time and only with the help of a simple pocket calculator and given formulas. The examination questions cover the entire lecture material. The answers require partly own formulations, partly multiple choice, and in addition to that calculations. No media are allowed except for a simple calculator.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Mathematics: solution procedures of differential equations (vibrations and waves), complex data.

#### **Content:**

Acoustics is the science of sound and its propagation. As a field of science, it encompasses all related aspects, such as the origin and generation, propagation, influence and analysis of sound, its perception by hearing and its effect on people.

The lecture conveys the acoustic basics for a professional activity in the building industry. Attention is paid to room and building acoustics.

- Basics of acoustics

- o Sound formation, propagation and perception
- o Mathematical basics, e.g. wave equation, calculation with sound levels
  
- room acoustics
  - o Room acoustic parameters
  - o Statistical reverberation theory
  - o Sound absorption and reflection, acoustically effective materials
  - Room-acoustic measuring methods
    - o Planning tools and modelling: beam geometry, computer simulation
    - o Design and construction rules in room acoustics
    - o Room acoustic measures for rooms for use with speech or music, e.g. lecture and conference rooms, offices, teaching, theatre, concerts
    - o Exercise, e.g. acoustic measures for a band rehearsal room
  
- Building acoustics (structural sound insulation in buildings)
  - o Airborne and impact sound insulation of building components
  - o Relationships for structure-borne noise and vibration protection
  - o Requirements depending on the use of the buildings
  - o Application of current calculation methods in building acoustics
  - o Constructions, measures and materials for building acoustics
  - o Measuring methods in building acoustics
  - o Exercise, e.g. design of components for a residential building
  
- Further aspects of sound insulation for building physics
  - o Urban noise protection, e.g. from road and rail traffic, industrial noise
  - o Noise immission protection
  - o Technical sound insulation, e.g. of technical building installations
  - o Vibration protection
  
- Excursion to the engineering office Müller-BBM (Planegg near Munich)
  - o Range of activities of building physicists in engineering offices
  - o Sound absorption coefficient measurement in the reverberation chamber
  - o Sound power measurement in the "anechoic chamber
  - o Sound insulation measurement on the test bench

### **Intended Learning Outcomes:**

After attending the course, students will be able to understand and calculate acoustic phenomena. Furthermore, simple acoustic problems can be identified and solved.

The students understand the theoretical basics of building acoustics including sound propagation outdoors. The associated standardization can be applied and its validity limits are understood.

The results of the acoustic modeling are understood. The difference between calculated single number values and subjective hearing perception is understood.



**Teaching and Learning Methods:**

The module consists of lectures and integrated exercises. The corresponding lectures are supported by PowerPoint presentations. The lecture material is also supported by exercises. If possible, smaller experiments and sound measurements as well as excursions will be carried out. Within the scope of the exercises, the students work out solutions to fundamental questions of building acoustics.

**Media:**

Powerpoint, exercises, experiments with measurements

**Reading List:**

- Cremer, Heckl: Körperschall
- Morse, Ingard: Theoretical Acoustics
- Long: Architectural Acoustics

**Responsible for Module:**

Klaus Peter Sedlbauer

**Courses (Type of course, Weekly hours per semester), Instructor:**

Akustik incl. Akustisches Laborpraktikum (Vorlesung, 2 SWS)

Gocht S [L], Gocht S, Meier A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV360011: Building Physics in Research | Bauphysik in der Forschung

Version of module description: Gültig ab winterterm 2018/19

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Exam duration (in min.): 60.

Proof of performance is provided in the form of a written examination. The students should prove that specific questions in the field of building physics research can be compiled, have been understood, can be presented in compressed form. This implies in particular current theoretical models in building physics. The examination questions cover the entire content of the lectures. The answers require own formulations, marking multiple choice answers, or own calculations. No tools are allowed except for a simple calculator.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Building Physics basic Module
- Building Physics Supplementary Module

#### Content:

Results, their interpretation and further development of current research in the field of building physics, communicated by guest speakers from different research areas. Examples and lectures focus on scientific building physics.

#### Intended Learning Outcomes:

After participation the students are able to develop theoretical models to describe complex processes in the field of building physics, which is an important ability for the preparation of a possible subsequent master thesis in the field of building physics.

**Teaching and Learning Methods:**

The course includes lectures and, if necessary, scientific workshops held by guest speakers from national and international research institutions. The content covers current research in building physics especially in thermodynamics, energy, lighting and acoustics.

Students are provided with further information on the individual topics in an online learning room. This enables the guest lecturers to engage an intensive exchange with the students, to answer questions promptly and personally and, if necessary, to carry out the experiments independently. These questions can then be discussed further in the online learning room and additional information on individual topics can be provided.

**Media:**

Powerpoint presentations blackboard

**Reading List:**

- Kohler, St., et.al.: Energieeffizienz von Gebäuden. Wüstenrot Stiftung, Karl Krämer Verlag Stuttgart + Zürich (2006).
- Gösele, K., Schüle, W., Künzel, H.: Schall, Wärme, Feuchte. Bauverlag Wiesbaden, 10. Auflage (1997).
- von Weizsäcker, E. U., Lovins, A., B., Lovins, L. H.: Faktor vier. Doppelter Wohlstand halbiertes Naturverbrauch. Droemer Knauer, München (1996).
- Bansal, N.K.; Hauser, G. und Minke, G.: Passiv Building Design. A Handbook of Natural Climatic Control. Elsevier Science B.V., Amsterdam, London, New York, Tokyo (1994).
- Hauser, G., Höttinger, K., Stiegel, H. und Otto, F.: Heizenergieeinsparung im Gebäudebestand. Hrsg.: Gesellschaft für Rationelle Energieverwendung (2001).

**Responsible for Module:**

Klaus Peter Sedlbauer

**Courses (Type of course, Weekly hours per semester), Instructor:**

Bauphysik in der Forschung (Vorlesung, 2 SWS)

Sedlbauer K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV380004: Microbiology of Groundwater Ecosystems | Mikrobiologie von Grundwasserökosystemen**

Version of module description: Gültig ab summerterm 2011

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

written exam

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basics in ecology and Microbiology

#### **Content:**

The course consists of an

-introduction to Groundwater ecosystems

" what makes them different

" porous vs. karst and fissured systems

" Organismic repertoire

" Energetic constraints

" Heterotrophy vs. Autotrophy

" Case study: lithoautotrophic ecosystems in caves (Frassassi, Movile)

-Microbiological basics - FAQs

" How is a bacterial cell composed

" How to convert biomass in cells assimilation efficiencies

" Growth in the subsurface How fast do microbes reproduce

" Transport and Migration rates - How fast can a bacterium swim

-Microbes in groundwater and aquifers

" The limits for life

- " Spatial and temporal distribution
- " Sessile vs. attached
- " Are there biofilms in aquifers?
- " Dormant vs. active
- " Case study: Distribution of bacteria in a pristine (Anif) and a contaminated (Flingern) aquifers

-Viruses in the subsurface

- " What is a virus
- " Natural and pathogenic viruses
- " Lytic vs. lysogenic viruses
- " The viral shunt component of the microbial food web
- " Viral control of microbial activities
- " Case study: The granitic aquifer of the ASPÖ hard rock lab in Sweden

-Microbial diversity in the subsurface

- " Conceptual frameworks
- " Methods to study microbial diversity
- " Driving forces
- " Case study: Selected hydrocarbon contaminated aquifers

-Microbial activity in the subsurface

- " Aerobic vs. anaerobic mode of living
- " Important anaerobic respirations
- " Thermodynamic constraints
- " Most important redox processes
- " Case study: The tar oil-contaminated aquifer in Flingern

-Trophic interactions in aquifers

- " Syntrophy, symbioses
- " Microbial food webs and trophic channels
- " Protozoa, Fungi
- " Groundwater Fauna
- " Case study: The karst systems of the Rax and Schnealpe

-Groundwater ecosystem services

- " Water purification and drinking water production
- " Biodegradation
- " Water balancing and GW dependent ecosystems
- " Microbes as bioindicators
- " Development of ecological sound assessment schemes
- " Case study: The UBA project

-Groundwater contamination and microbial biodegradation

- " Priority contaminants in groundwater

- " Future contaminants
- " Groundwater legislation and EU-WFD
- " What is degradable and what not?
- " Case study: Aromatic hydrocarbons
  
- Characterization of microbial communities
  - " Molecular community analyses
  - " Identification of key-players
  - " Determination of in situ activities
  - " Labelling as a tool to identify key-processes
  
- Life in the deep subsurface
  - " Is there life independent from land surface?
  - " Radiolysis, geogenic electron donors
  - " Microbiology of deep geothermal waters
  
- (Bio)Remediation strategies for contaminated groundwater
  - " Injection of electron acceptors / donors
  - " Bioaugmentation
  - " Reactive barriers
  - " Monitoring of natural attenuation

This module can be seen as an advanced class building up partly on the lectures on 'Basics of Ecology' and 'Microbiology'.

#### **Intended Learning Outcomes:**

Students are able to estimate the microbiology and biogeochemistry of groundwater ecosystems, which is essential for the understanding of subsurface processes including formation of geological units as well as the transport and degradation of contaminants.

#### **Teaching and Learning Methods:**

Teaching methods will include, besides the classical presentation mode, interactive work ( e.g. discussion individual tasks and working on exercises in small groups). Students will be actively integrated in the teaching and learning process applying state of the art educational tools. Applied exercises related to daily life problems and short movies will complement the lectures.

#### **Media:**

Beamer, handouts

#### **Reading List:**

Chappelle, F.H. (2000) Ground-Water Microbiology and Geochemistry, Wiley; Griebler, C. & Mösslacher, F. (2003) Grundwasser-Ökologie, UTB-Facultas, Wien. Specific literature will be distributed in form of scientific articles.

**Responsible for Module:**

Brigitte Helmreich (b.helmreich@bv.tu-muenchen.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV380009: Applications of Urban Climate | Urban Climate - Anwendungen**

Version of module description: Gültig ab summerterm 2012

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>70   | <b>Contact Hours:</b><br>110         |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Students work on a project and present their results.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Fundamentals of Urban Climate (recommended but not compulsory!)

#### **Content:**

- Introduction to applied urban climatology
- Data survey in an urban environment in Munich
- GIS-based simulation
- Analysis and evaluation of the results
- Presentation of the results

#### **Intended Learning Outcomes:**

After completing the module students will be able to apply theoretical models of urban climatology, to design and undertake measurements and surveys for the necessary input data, to analyse data of urban climate models by the means of GIS and evaluate the results.

#### **Teaching and Learning Methods:**

Short theoretical input, project and field work, computer lab work, presentation

#### **Media:**

Presentation, computer work, field work, instruments and sensors for data surveys



**Reading List:**

**Responsible for Module:**

Brigitte Helmreich, Dr. (b.helmreich@bv.tu-muenchen.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV400009: Land Management and Land Policy | Bodenordnung und Bodenpolitik

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment method is project assessment. The students must present a group work executed the entire module period (1 hour per week) on a topic related to land management and land policy. The topic will be communicated to the students in due time. Through presentations students should demonstrate that they are able to investigate given case study projects. This includes, depending on the topic, objectives of the projects, theoretical and conceptual idea of the project and implementation measures undertaken. Furthermore, the students will analyse and assess the results, and will develop and derive conclusions. The group work will be presented in form of PowerPoint presentation of 10 minutes, by which its scientific quality, comprehensiveness, and appropriateness with regard to the topic assigned will be verified. Furthermore, compliance with all formalities (referencing, use of language, etc) will be considered. The presentation will be followed by question session of 10 minutes. Each student also writes an individual paper. The final mark will be based on both the group work and the individual work (50/50).

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

## **Content:**

### **i. Introduction**

Some basic facts and data on global trends including population growth, distribution of natural resources, wealth and poverty, income and population, consumption and production schemes are provided as a base for further discussion. Different definitions, concepts, measurements and indicators of global land problems will be presented and discussed.

### **ii. Land policy and land governance for sustainable development**

Students will understand the concepts of land tenure system and tenure security. Furthermore, they will learn the importance of a comprehensive land policy and good land governance as a basis for poverty reduction, sustainable resource management and economic growth. They will be introduced to the following crucial elements of a coherent land policy:

- The employment of democratic rules, rules of law and law enforcement, participation and transparency to control power and thus avoid land related corruption, land concentration and land grabbing.
- Conveying a vision of the desired development path.
- Focusing on an evolutionary process of change that supplants social upheaval and revolution, including intensive government-citizen dialogue and dialogue within civil society.

### **iii. Land registration and cadastre system**

During the lecture the students will learn about basic concepts of land registration and cadastre system. They will discuss different country case studies and compare different cadastre and registration systems in the world and they will be familiar with general characteristics of these systems.

### **iv. Rural development issues**

Limited opportunities, inappropriate assets and capabilities, institutional deficiencies, and unbalanced power structures will be identified as main causes for rural mass poverty. The strategic dimensions and the guiding principles of rural development will be introduced and discussed, as there is the economic, social, political and ecological dimension. Furthermore, students will learn about the principles of rural land consolidation as well as about the principles of village renewal.

### **v. Regional and urban development issues**

Positive regional and urban development is committed to promoting sustainable cities, town and countryside that fulfil the promise of development for their inhabitants -- in particular, by improving the lives of the poor and promoting equity -- while contributing to the progress of the country as a whole. Furthermore, lessons on regional and urban development deal with issues such as housing and urban regeneration. Beyond general theories, students are familiar with regional and urban development practices in EU, Germany and Munich.

## **Intended Learning Outcomes:**

After this module the students are able to discuss and recognise the potentials and limits of various international agreements that have been ratified by the international community to protect land and other natural resources in order to regulate their use and to ensure equitable access to them. The

students also appreciate international frameworks for land management and land tenure and are able to analyse topics related to land management and land tenure in line with global and local contexts. Participants also understand the principles of land registration and with different types of cadastre and land register. Furthermore, the students are familiar with diverse implementation aspects of land management.

Students are familiar with development theory as well as development policy and are acquainted with the basic principles and current trends in this field. They are also able to critically discuss theoretical and political approaches as well as their benefits and restrictions. Beyond general theory, students are familiar with concrete concepts for urban and rural development and different approaches including village renewal and land consolidation.

**Teaching and Learning Methods:**

Lecture and seminar are held as type of instruction. Teaching method includes presentation, individual and group works and case studies analysis. Through noted methods students are able to understand land management and land policy framework in different countries. Furthermore, the students are able to analysis different cases with respect to theories and its practice in the field.

**Media:**

PowerPoint presentations and handouts

**Reading List:**

A collection of relevant and up-to-date / recent articles and background reading materials will be handed out during the sessions. In additon, students need to find thier own background materials for both the group work and individual work

**Responsible for Module:**

Dr. Uchendu Eugene Chigbu

**Courses (Type of course, Weekly hours per semester), Instructor:**

Land Policy and Land Governance (Vorlesung, 2 SWS)  
de Vries W [L], Duran Diaz P

Environmental Planning and Land Management - Seminar (Seminar, 2 SWS)

Duran Diaz P [L], Duran Diaz P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV400021: Instruments of Land Mobilization | Instrumente der Bodenordnung und Landentwicklung

Version of module description: Gültig ab summerterm 2020

|                                         |                             |                                  |                                      |
|-----------------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module requirements are brought by a written exam in the form of a Klausur.

Without any tools the students should repeat the current challenges, components and instruments of sustainable development, equal access and use of land. In their own words they should explain the connections between land tenure security and sustainable land management within an international context.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Modul "Land Management 1" (BV000117)
- Modul " Basics of Spatial Planning" (BV260030)

#### Content:

- basics of land management in an international context
- current theoretically issues and problems
- current practical international examples

#### 1. Global Trends and Land Administration

2. Cadastre and land registration
3. Land policy and land governance
4. Role of Spatial Data Infrastructure in Land Management
5. Land management & land tenure
6. Land use planning
7. Regional and urban development
8. Rural land management: village renewal & land consolidation
9. German International Cooperation in the field of land management
10. case studies

**Intended Learning Outcomes:**

After participating in the module the students know the instruments und components of land management. They understand that economic growth, peace, justice and protection of natural resources worldwide require legal security of land. They are able to recognise the contribution of land management for a sustainable development and to value the effectiveness of the instruments.

**Teaching and Learning Methods:**

Teaching method: lecture

Learning method: interactive lecture for to give expert knowledge.

**Media:**

Power Point Presentations

**Reading List:**

**Responsible for Module:**

Walter Timo de Vries (wt.de-vries@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Instruments of Land Mobilisation (Vorlesung, 3 SWS)

de Vries W [L], de Vries W

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV410005: Hydraulics Lab | Hydraulik Praktikum

Version of module description: Gültig ab winterterm 2011/12

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>60  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module is examined by a written exam (60 min.) and a non-graded course achievement. Performing and evaluating outdoor experiments in groups the students demonstrate that they are able to apply the measurement techniques and to analyse the results.

The written exam test their knowledge on the single measurement techniques as well as their evaluation procedure. This exam additionally examines that the students are able to evaluate flow situations in a set time frame and pick a applicable measurement technique for the given situation. The only aids allowed during the exam are a handwritten A4-sheet and a non-programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Prerequisite for this module is the successful completion of the module Fluid Mechanics and Groundwasser (BGU41016) respectively Fluid Mechanics and Turbulence (BV410013).

#### Content:

Theory and practice of flow measurements in natural and man-made channels:

- measurement of depth (ultra sonic, pressure, point gauge)
- hydraulic measurement techniques (venturi channel, measurement wears, flow rate determination using to flow depths)
- salt dilution gauging
- velocimetric techniques (hydrometric impeller, magnetic-inductive current meter, acoustic doppler velocimeter)

#### Intended Learning Outcomes:

After successful completion of this module students are able to:

- explain the different ways to measure flow depth and current
- perform experiments in a team
- measure current in natural and man-made channels using the learned methods
- analyse the results of the flow measurements
- evaluate the applicability of a measurement method to a given flow situation

**Teaching and Learning Methods:**

This lab course consists of three parts: the presentation of the measurement techniques in short talks, the application of the techniques in outdoor experiments and the evaluation of the results. To foster the students capacity for teamwork the students will form small “research teams”. Within these teams they develop short talks on two measurement techniques and are then experts of this techniques for the rest of the semester. The outdoor experiments are then performed and evaluated by bigger groups of about 4-6 students. At the end of the semester each group turns in a protocol and a report of the experiments. By this the students learn the workflow of an experimenter, research of fundamentals, work as a research team, performing and recording of experiments as well as their evaluation.

**Media:**

slides, black/white board, script, outdoor experiments

**Reading List:**

Bollrich, G.: Technische Hydromechanik, Bd. 1, Huss Medien, Berlin (2007)  
Norm DIN V 19218: Durchflussmessung in Fluiden - Verfahren zur Unsicherheitsermittlung (2008)  
Norm ENV 13005: Leitfaden zur Angabe von Unsicherheiten beim Messen (1999)  
Landesanstalt für Umweltschutz Baden-Württemberg (Hrsg.) Durchflussmessung mit der Salzverdünnungsmethode (2002)  
Maniak, U.: Hydrologie und Wasserwirtschaft, eine Einführung für Ingenieure, Springer-Verlag, Berlin (1993)

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydraulik Praktikum (Praktikum, 2 SWS)

Quosdorf D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV410009: Numerical River Hydraulics | Numerische Gerinnehydraulik [NRH]

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination will be written and lasts 60 minutes, all aids will be allowed. Employing questions and small calculation problems the application of theoretical and practical fundamentals will be tested. Additionally the students show, that they are able to characterize the different numerical methods for solving shallow water equations and to evaluate the calculation results according to plausibility.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Prerequisite of this module is the module Applied Hydromechanics (BGU41018T2) and the module Fluid Mechanics and Ground Water Hydraulics (BGU41016) respectively Fluid Mechanics and Transport Mechanisms (BGU41020).

#### Content:

- basic equations of hydromechanics (Navier-Stokes-equation): derivation conservation of mass and momentum, approach to a numerical solution, boundary conditions
- shallow-water equations (2D-St.Venant differential equations): derivation, characteristics, scope of application, boundary conditions
- basics of numerical solvers: discretization of differential equations, numerical grids, numerical approximation, properties of numerical methods
- application of theory using different flow solvers in OpenFOAM for a couple of examples

#### Intended Learning Outcomes:

On successful completion of this module the students are able to:

- apply the basics of theory and code of a 2D-shallow-water program

- model real flow situations in the software
- characterize numerical methods to solve the shallow water equations
- perform simulations using a program which was developed during class
- control the results of the performed simulations using estimations
- evaluate the results of the performed numerical simulations

**Teaching and Learning Methods:**

The module Numerical River Hydraulics consists of two courses:

A classical lecture developing the theory on the black board and a computer lab applying the theory. In the computer lab the basics learned in the lecture will be applied and deepened using the open source software OpenFOAM.

During the semester exercise problems will be provided, which will be solved in groups. These problems encourage the connection of the theory taught in the lecture and the practical application in the lab. The students will work on these exercises at home as well as during the computer lab.

**Media:**

script , black / white board, notes, codes on the computer, computer work

**Reading List:**

- C.J. Beffa, Praktische Lösung der tiefengemittelten Flachwassergleichungen, PhD thesis, ETH Zürich, 1994
- J.H. Ferziger und M. Peric, Computational Methods for Fluid Dynamics, Springer, Berlin, 2002
- P.G. Franke, Hydraulik für Bauingenieure, Walter de Gruyter, Berlin, 1974
- P. Moin, Fundamentals of Engineering Numerical Analysis, Cambridge University Press, Cambridge, 2001

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Michael Manhart (michael.manhart@tum.de)

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV410011: Hydro Project | Hydroprojekt

Version of module description: Gültig ab winterterm 2019/20

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The students prove the acquisition of competence by doing a project work which contains a written evaluation and a corresponding presentation in the fields of numerical simulation of river flow or experimental characterization (flow measurements, kolmation experiments). Essential parts are a description of the problem definition, used solution methods as well as a presentation and evaluation of the results. The written evaluation should have a length of 20-50 pages. The duration of the presentation is approx. 20 min. With the written evaluation, the students prove that they can independently identify a hydromechanical problem and investigate it using numerical or experimental methods, and that they can scientifically evaluate and document the results of their investigations. Through the presentation, the students demonstrate that they are able to present the results of all project phases in a structured manner. The written elaboration and the presentation are included in the module grade at a ratio of 75:25. When group work is carried out, the individual performance of each participant is evaluated in the preparation of the written evaluation and in the presentation.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Prior participation in the module Fluid Mechanics and Groundwater Hydraulics (BGU41016) is recommended

#### Content:

- Special topics of hydromechanical applications, e.g. flow simulations, discharge measurements
- Methods of scientific knowledge acquisition, documentation and presentation.
- Processing of a project in the field of Hydromechanics (numerical simulation of river flow, investigation of the kolmation process in rivers)
- Applying of hydromechanical basic knowledge, experimental and numerical methods.

- Assessment of hydromechanical results and estimations.

**Intended Learning Outcomes:**

After successful completion of this module, the students are able to:

- explain the results of their research
- perform independent research on scientific results of applied hydromechanical problems
- investigate problems using experimental and numerical methods
- evaluate the results of the their independently carried out projects

**Teaching and Learning Methods:**

The module consists of a seminar and a project, which built on one another. At the beginning of the semester a topic will be set, e. g. water hammers in sewage channels (WS 2011/2012). In the seminar, amongst others, there will be talks by external speakers to gain a deeper understanding of the topic. In addition the students will be asked to give a talk on a certain field within the topic. Preparing the talk will encourage them to do research on the topic and to prepare the results gained in a way such that they can be presented to others.

Conducting the project will give the students the chance to apply the knowledge gained in the seminar. This will be done by either performing an experiment in the hydromechanical lab or in a numerical study. While writing the project report at the end the students will learn how to keep record and evaluate scientific results.

**Media:**

The media include optionally: presentations, films, online wiki, e-learning content

**Reading List:**

Boiten, W.: Hydrometry - a comprehensive introduction to the measurement of flow in open channels CRC Press, 2008

Ferziger, J. H.: Computational methods for fluid dynamics, Springer, 1997

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydroprojekt / Vertieferprojekt (Projekt, 2 SWS)

Brosda J, Unglehart L, von Wenczowski S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV410013: Fluid Mechanics and Turbulence | Fluidmechanik und Turbulenz

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcomes are assessed by a written exam (120 min.). The students prove that they are able to solve exercises that require knowledge on the fundamental principles of fluid mechanics. This includes e.g. the application of the Navier-Stokes equations, the momentum theorem or the law of the wall of a turbulent boundary layer. Furthermore questions on the basics of turbulence, scaling and strategies of the simulation of turbulent flows have to be answered. Also exercises from the area of turbulence modeling have to be solved to prove an understanding of the content. Admitted auxiliary means are a DIN A4 sheet (2 pages) containing handwritten notes and a non-programmable pocket calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Prerequisite for this module is the module Hydromechanics (BV00013) or equivalent and knowledge in vector and tensor calculus.

#### Content:

- continuum hypothesis
- calculus
- kinematics
- equations of motion in differential form
- dimensional analysis
- boundary layer
- repetition of the engineering fundamentals of fluid mechanics
- introduction to turbulent flow
- mechanisms of turbulence generation

- turbulent spectra
- direct numerical simulation (DNS)
- Reynolds-Averaged-Navier-Stokes (RANS)
- large-eddy simulation (LES)
- comparison RANS-LES

### **Intended Learning Outcomes:**

On successful completion of this module the students are able to:

- explain the utilization of the concept of a continuum in fluid mechanics
- understand the phenomenology of turbulent flow, its description by mean values and fluctuation as well as the concept and the structure of a (turbulent) boundary layer
- understand modeling of turbulent flow in the context of Reynolds-averaging and with the help of large-eddy simulation
- apply the Navier-Stokes equations for the incompressible case, the law of wall for turbulent flows, as well as universal scaling laws of turbulent flow to selected flow cases
- select numerical grids for turbulent near wall flows
- characterize flow fields with the help of flow lines (stream lines, path lines, streak lines) and by the strain rate tensor and the rotation rate tensor
- determine a set of non-dimensional parameters for a given physical system
- assess the impact of selected non-dimensional parameters (the Reynolds number, in particular) on the flow
- determine forces, pressure and velocities that act on the boundaries of a flow domain by means of simple tools within a short time
- estimate the suitability of the methods RANS and LES for the computation of a given type of quantity in a turbulent flow, considering reliability, cost and reliability of modeling, computing time and accuracy

### **Teaching and Learning Methods:**

The module consists of the lecture Fluid Mechanics and the course Turbulence Modeling, which can be subdivided into a lecture and an exercise. While the Fluid Mechanics is offered during the whole semester, the Turbulence Modeling is held as a block lecture, that starts at a later time. This offers the students to gain fundamental knowledge in the field of fluid mechanics, which can be built upon in the Turbulence Modeling. As type of instruction, a lecture is chosen because it supports the theory based character of the content (laws of conservation, fundamental equations of fluid mechanics), which is predominantly derived at the black board by the lecturer and complemented by presentation slides. The application and relevance of the derived principles are illustrated with concrete examples. The students are encouraged to explore the literature during their preparation and follow-up of the lecture and compare different ways of presentation and derivation of the facts.

For both parts of the module there is non-compulsory homework. This provides an opportunity for the students to apply their knowledge to selected simple problems and test their learning outcome on regular bases. Complementary, a non-compulsory tutorial (90 min.) is offered for the Fluid Mechanics. Here, the tutor gives assistance with reviewing the lecture and solving the homework. In the course Turbulence Modeling, the understanding of the concepts of modeling is achieved by

means of simple turbulent flow cases. Therefore, the students develop simple codes and evaluate them. The results are discussed together with the lecturer in the exercise.

**Media:**

black / white board, presentation slides, videos, exercise sheets, e-learning

**Reading List:**

G. K. Batchelor. An Introduction to Fluid Dynamics. Cambridge University Press, 1967.  
I. G. Currie. Fundamental Mechanics of Fluids. McGraw-Hill, New York, 1974.  
P. K. Kundu and I. M. Cohen. Fluid Mechanics, Third Edition. Elsevier, Amsterdam, 2004.  
R. L. Panton. Incompressible flow. John Wiley and Sons, Inc, Hoboken, third edition, 2005.  
D. J. Tritton. Physical Fluid Dynamics. Van Nostrand Reinhold, New York, 1977.  
M. van Dyke. An Album of Fluid Motion. Parabolic Press, Stanford, California, 1982.  
S. B. Pope. Turbulent flows. Cambridge University Press, Cambridge, 2000.  
H. Tennekes and J. L. Lumley. A first course in turbulence. The MIT Press, Cambridge, Massachusetts, 1972.

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Fluidmechanik (Vorlesung, 2 SWS)

Manhart M, Quosdorf D, Sakai Y

Fluid Mechanics and Transport Mechanisms (Vorlesung, 4 SWS)

Manhart M, Sakai Y, Quosdorf D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV410015: Energy Efficiency | Energieeffizienz

Version of module description: Gültig ab summerterm 2013

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>2          | <b>Total Hours:</b><br>60  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>15          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

This modul is examined by a 60 minutes written exam. The only aid allowed are, lecture slides, the students own notes taken during the lecture and a non-programmable calculator.

Using short questions the understanding of the fundamentals of energy efficiency is tested.

Additionally

In the exam Sankey diagramms need to be analysed and calculations to analyse data according to their energy efficiency have to be performed. Furthermore practical examples need to be evaluated according to their energy efficiency and possible efficiency enhancements.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basic engineering understanding (electric, mechanical, thermodynamics, physics, civil engineering) is appreciated

#### Content:

- Basics of energy efficiency evaluation
- Drawing and calculation of Sankey diagrams
- Application of balance calculations
- Understanding of different energy efficiencies (resources, back-draft, energy)
- Efficiency in energy economy (electric generation, electricity transportation and the impact on cost, environment, labor and resources)
- eMobility and efficiency in comparison of the systems and conventional gasoline based mobility (power supply, efficiency consideration for drive train, tank to wheel, well to wheel)
- Examples for energy efficiency in different areas: -Power generation with coal, gas, renewables
- Power transportation in different electric grids
- Resource analysis



- Energy efficiency in lighting (Bulb, CFL, LED with weighting and calculation)
- Information technology and eMobility regarding eMobility
- Commercial buildings (process, no constructive efficiency)

**Intended Learning Outcomes:**

After successfully passing this course, the students are able to:

- explain the fundamental terms of energy efficiency, and of the components needed to determine energy efficiency
- describe different kinds of energy efficiency
- perform energy efficiency calculations
- evaluate efficiency improvement in different fields: e.g. energy economy, electricity transmission, e-mobility

**Teaching and Learning Methods:**

The lecture is thriven by the hugh pool of experience of the lecturer in field of energy generation and energy efficiency. Besides a classical talk accompanied by slides the student are encouraged to join the discussion on several examples in class. The contents of the course are aquired toghether with the students in the following manner: problem statement, discussion of possible solutions and discussion of resulting scenarios. All slides will be provided on the eLearning platform.

**Media:**

slides

**Reading List:**

script

**Responsible for Module:**

Michael Manhart (michael.manhart@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Effizienter Umgang mit elektrischer Energie (Vorlesung, 1 SWS)

Mayer O, Quosdorf D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV430005: Stability of Structures | Stabilitätstheorie

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcome of the Stability of Structures module is confirmed by passing a 60 minute written examination.

The aim of the examination is the confirmation that the key concepts (Stability phenomena, fundamental differential equations and the corresponding solutions) as well as the applications for problems have been understood and can be concisely recalled and implemented. Furthermore, problems must be analyzed and solution approaches found within a limited time using the learning outcomes achieved during the module.

The solutions sometimes require the student's own interpretation, in part selection of single or multiple choice answers, whereby the emphasis is on short calculation exercises.

No auxillary means are allowed in the examination with the exception of a collection of formulae (provided) and a scientific calculator.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basic knowledge of mechanics

#### Content:

In this module the local and global failure mechanisms are discussed. Non-linear problems will be handled generally and dealt with in a linear form. Stress and stability problems will be derived mathematically and mechanically with the example of a bending beam and solved. Analytical solutions will be presented complementing the generally valid numerical implementation with help from Finite Element Methods.

The thematic outline is as follows:

- Non Linear effects and theory of 2nd order
- Stress problems and stability phenomena
- Stability problems: buckling, toppling, torsional buckling, lateral torsional buckling
- Numerical solution with Finite Element Method

**Intended Learning Outcomes:**

After successfully participating in this module the students can analyze characteristic stability phenomena and their mechanical basis as well as understand the differential equations that underlie the problems. They are able to evaluate the results and can, after finishing the exercises, analyse the stability characteristics of structures using mechanical models.

**Teaching and Learning Methods:**

Instead of an ordinary lecture, teaching videos are provided via Moodle. Due to this new approach, students are able to study the complex contents of the module with their individual speed. Exercises are offered to support the students in applying the basics and concepts taught in the videos to problem cases. Depending on the needs, students will be supplied with exercise sheets to help deepen their understanding and practical application. For validation reasons and to give an insight into praxis, the results of the calculation exercises are compared to the results of a commercial finite-element software.

**Media:**

Teaching videos are provided via Moodle. Tablet PC and digital projector, transparencies or the blackboard may be used during the sessions in the lecture hall. Exercise sheets and tasks may be published online as required. Animations will be used at appropriate points to illustrate the learning contents.

**Reading List:**

- W. Wunderlich, G. Kiener, Statik der Stabtragwerke, Teubner 2004
- C.H. Yoo, S. Lee, Stability of Structures: Principles and Applications, Butterworth Heinemann 2011

**Responsible for Module:**

Prof. Dr.-Ing. Gerhard Müller

**Courses (Type of course, Weekly hours per semester), Instructor:**

Stability of Structures - Übung (Vorlesung, 2 SWS)

Weber F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV440004: Parallel Computing | Paralleles Rechnen

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcome is confirmed by passing a written exam of 60 minutes. The exam is provided during the allotted time via moodle. During the exam, students join a video conference with the examiner. Students solve the tasks on own paper and send a digital copy of their solution to the examiner within 5 min after the exam. Furthermore, the original solution has to be send via postal service to the chair for correction.

The aim of the exam is to demonstrate familiarity with the discussed topics as well as their ability to apply learned methods and concepts to specific problems from the field of parallel computing. These include parallel architectures and networks, parallel programming and algorithms. Therefore, short (arithmetic) problems have to be solved and code fragments have to be implemented on paper. Additional resources that are allowed throughout the examination are printed lecture slides and hand-written notes.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Knowledge of any programming language (for instance C/C++ or Fortran)
- Participation of lecture Algorithms & Data Structures (BV440007)

#### Content:

- modern computer architectures (pipelining, vectorisation, many/multi-core)
- classification of supercomputers (Flynn's taxonomy, memory-coupled systems)
- evaluation (speed-up and efficiency, model of Amdahl and Gustafson) and scalability
- computer networks as well as examples of static and dynamic network topologies
- foundations of parallel programmes (Bernstein conditions, parallelisation models, synchronisation and communication)

- analysis and programming of memory-coupled systems (cache coherence, MESI protocol, loop dependencies, OpenMP)
- analysis and programming of message-coupled systems (message passing, collective and point-2-point communication, MPI)
- static/dynamic load balancing schemes and space-filling curves
- examples of parallel applications (matrix-vector multiplication, matrix-matrix multiplication, iterative solvers for linear systems, bitonic sorting)

### **Intended Learning Outcomes:**

After successful participation students are able to

- understand the concepts of modern computer architectures and to show differences in their processing schemes,
- analyse network topologies and evaluate them regarding their key features,
- apply design patterns and paradigms of parallel programs and to transfer them on own problems,
- understand and classify latest trends in hardware design as well as to evaluate their benefits for the usage with own parallel programs,
- develop own parallel codes based on OpenMP or MPI,
- assess the performance of parallel programs based on evaluation techniques,
- apply load balancing strategies and to analyse their benefits.

### **Teaching and Learning Methods:**

The module is provided as lecture plus integrated exercises. Lecture contents will be communicated with descriptive and practical examples as well as discussions with students. The lecture should further motivate students to own researches and lecture studies concerning the topics. Exercises (based on weekly exercise sheets) that reflect the respective lecture contents will be processed together with students in order to apply and foster learned methodologies and concepts.

### **Media:**

Main lecture media are PowerPoint slides complemented by the usage of black and white boards. PowerPoint slides are online available for download.

### **Reading List:**

- I. Foster: Designing and Building Parallel Programs, Addison-Wesley, 1995, and evolving online version
- A. Grama, A. Gupta, G. Karypis, V. Kumar: Introduction to Parallel Computing, Addison Wesley, sec. ed. 2003
- H. F. Jordan, G. Alagband: Fundamentals of Parallel Processing, Prentice Hall, 2002
- E. L. Leiss: Parallel and Vector Computing, McGraw-Hill, 1995
- B. P. Lester: The Art of Parallel Programming, Prentice Hall, 1993
- M. J. Quinn: Parallel Programming in C with MPI and OpenMP, McGraw-Hill, 2003
- H. Sagan: Space-Filling Curves, Springer, 1994

- T. Schnekenburger, G. Stellner (Hrsg.): Dynamic Load Distribution for Parallel Applications, Teubner, 1997

**Responsible for Module:**

Christoph Ertl ([christoph.ertl@tum.de](mailto:christoph.ertl@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV440007: Algorithms and Data Structures | Algorithmen und Datenstrukturen

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Learning success will be verified via a 90 minute written examination, in order to show students' familiarity with the discussed topics as well as their ability to apply learned methods and concepts to develop and analyse algorithms for specific problems from the field of recursive approaches, sorting and searching as well as graphs. Therefore, short problems have to be solved and code fragments have to be implemented on paper. Additional resources that are allowed throughout the examination are printed lecture slides and hand-written notes.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Knowledge of any programming language (for instance C/C++ or Fortran)

#### Content:

- Foundations of programming concepts
- Recursive algorithms
- Introduction into the complexity analysis of algorithms
- Data structures (arrays, trees, linked lists)
- Sorting algorithms (sequential approaches, divide-and-conquer approach)
- Search algorithms (sequential and recursive approaches, balancing, hashing)
- Foundations of graph theory and graph applications (minimal-spanning trees, shortest-path-search, maximum network flow)
- Code optimisation and cache-blocking algorithms

#### Intended Learning Outcomes:

After successful participation students are able to

- develop algorithms and, thus, to formulate rules using programming concepts in order to solve problems with the help of computers,
- understand recursive approaches and to apply them on own problems,
- analyse and classify algorithms concerning runtime and memory usage via a complexity evaluation,
- know different data structures and according to their strong and weak aspects to choose appropriate structures for specific problem classes,
- know, understand, and apply different sorting and searching algorithms together with their respective runtime and memory complexity,
- understand the foundations of graph theory and to apply graph-based algorithms for questions regarding minimal-spanning trees, shortest-path-search, and maximum network flow,
- know and understand methods for code optimisation (such as cache-blocking) and to apply them on own problems.

### **Teaching and Learning Methods:**

The module is provided as lecture and its contents will be communicated with descriptive and practical examples as well as discussions with students. The lecture should further motivate students to own researches and lecture studies concerning the topics. Exercise sheets (and solutions) that reflect the respective lecture contents will be provided, thus students can use those for their own control when studying and applying the learned methodologies and concepts.

### **Media:**

Main lecture media are PowerPoint slides complemented by the usage of black and white boards. PowerPoint slides are online available for download.

### **Reading List:**

- T.H. Cormen, C.E. Leiserson, R.L. Rivest, C. Stein: Introduction to Algorithms, 2nd ed., The MIT Press, 2001
- R. Sedgewick: Algorithms, 2nd ed., Addison-Wesley, 1988
- V. Heun: Grundlegende Algorithmen, Vieweg, 2003

### **Responsible for Module:**

Alexander Braun (alex.braun@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

PD Dr. rer. nat. habil. Ralf-Peter Mundani

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### **BV450005: Satellite Altimetry and Physical Oceanography | Satellitenaltimetrie und Physikalische Ozeanografie [AltiOcean]**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

With an oral examination it shall be ensured that the students are able to remember and to understand the individual concepts of physical oceanography, the observation technique of satellite altimetry, and the products derived from it. They should verify that they are able to build interrelations between the observational component of satellite altimetry and the physical processes of oceanography, and that they are able to understand their contribution to the overarching concept of system Earth. By means of dedicated questions, it is verified that the students are able to interpret results of observation technologies and that they are able to build connections to physical modelling. The format of an oral exam allows interactive queries, and the ability to give precise and well-structured answers in real time is verified.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Mathematical physics, linear algebra, time series analysis

#### **Content:**

Oceanography and Satellite Altimetry:

- Equation of motion,
- geostrophic currents,
- hydrostatic balance,
- temperature, salinity, and density,
- ocean tides, tidal analysis,
- de-aliasing,
- radar and laser altimetry,
- altimeter mission overview,
- where to get what data,
- corrections of altimeter observations,
- repeat pass and crossover analysis,
- mean sea surface, geoid, dynamic ocean topography, sea level variability, sea level rise.

### **Intended Learning Outcomes:**

After the successful conclusion of the module, the students are able to

- to understand the basic principles of physical oceanography;
- to understand the basic principles of satellite altimeter missions
- to recognize satellite altimetry as an operational remote sensing technique with important applications in geodesy, oceanography and other geosciences;
- to apply observation techniques and the necessary measurement correction;
- to apply key analysis methods to practical problems of satellite altimetry and physical oceanography;
- to analyze and to interpret the results;
- to link these topics to the monitoring of the Earth system.

### **Teaching and Learning Methods:**

Power point presentations; handouts in electronic form; blackboard

### **Media:**

- presentations in electronic form
- blackboard
- Selected text books and scientific publications

### **Reading List:**

Stewart, R.: Introduction to Physical Oceanography (OpenSource Book, see download)

Fu, L.L. and A. Cazenave (Eds.) Satellite Altimetry. International Geophysics Series, Vol. 69, San Diego, CA, 2000

### **Responsible for Module:**

Roland Pail (pail@bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Satellite Altimetry and Physical Oceanography (Vorlesung, 2 SWS)

Seitz F [L], Passaro M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV460012: Rivers as an Ecosystem | Fließgewässer als Lebensraum [KS\_4]**

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The written module examination (120 min) consists of two thematic fields, in which the students have to answer simple questions on eco-hydraulics and aquatic ecology without any tools. In addition, the understanding of the learned design methods will be examined by simple transfer tasks, which are based on the presented examples. Further, there will be questions regarding the interdisciplinary understanding (cross-cutting on: hydraulic - eco-hydraulics - aquatic ecology).

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Participation in modules:

"Grundmodul Wasserbau und Wasserwirtschaft", module no. BV000030

and

"Ergänzungsmodul Wasserbau und Wasserwirtschaft", module no. BV000048

#### **Content:**

The module combines the two topics Eco-Hydraulics and Aquatic Ecology, thus comprehensively treating the habitat in watercourses.

Eco-Hydraulics:

- Flora and fauna in and around river basins; meadow vegetation
- Interaction between the river and catchment area
- Continuity: requirements, possible forms, structural realization, regulations

- Design and calculation of fishways and ramps
- Water Framework Directive Water Act

**Aquatic Ecology:**

- Aquatic habitats and aquatic ecosystem types; life support services and threats; gas budget, trophic interactions, nutrients and their dynamics
- lotic ecosystems as dynamic systems: specific features, functions and threats, river continuum concept, bioindication
- lentic ecosystems: ecological classification, specific features, threats,
- case studies: biodiversity, extinction and threats to aquatic ecosystems; conservation biology concepts
- ecotoxicological aspects: endpoints, xenobiotics and endocrine disruptors; human impacts and effects of use on aquatic ecosystems

**Intended Learning Outcomes:**

After attending the module the students are able to:

- understand the basics of ecology and chemistry of waters and the interdisciplinary relationships and specific characteristics of aquatic ecosystems
- apply the design rules to retrieve the river continuity
- analyse the temporal and spatial distribution of biodiversity and productivity in aquatic ecosystems
- estimate and assess effects of human intervention on aquatic ecosystems

**Teaching and Learning Methods:**

The module consists of a lecture. The theoretical course contents are presented by the lecturer and supported by PowerPoint presentations and whiteboard notes. Accompanying exercises and discussions of relevant case studies allow students to participate and to intensify learned contexts. As a part of the lecture, field-specific group work in the classroom is included, in which the students solve simple calculation and discuss case studies independently and present their results afterwards.

**Media:**

Blackboard; PowerPoint presentation; Calculations

**Reading List:**

Schwörbel, Jürgen: Einführung in die Limnologie, Springer Spektrum 2013, ISBN-13: 978-3827421531

Primack, Richard B.: A primer of Conservation Biology, Palgrave Macmillan 2004, ISBN-13: 978-0878937288

Pullin, Andrew S.: Conservation Biology, Cambridge University Press 2002, ISBN-13: 978-0521644822

Helfman, Gene S.: Fish Conservation, Island Press 2007, ISBN-13: 978-1559635967

Postel, Sandra & Richter, Brian: Rivers for Life: Managing water for people and nature, PAPERBACKSHOP UK IMPORT 2003, ISBN-13: 978-1559634441

Di Giulio, Richard T. & Hinton, David E.: The toxicology of fishes, CRC Press, 2008, ISBN 0203647297, 9780203647295

**Responsible for Module:**

Dr.-Ing. Markus Reisenbüchler (markus.reisenbuechler@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Rivers as an Ecosystem (Vorlesung, 4 SWS)

Rüther N [L], Rüther N, Geist J, Reisenbüchler M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV460017: Hydro Power und Energy Storage | Wasserkraft und Energiespeicherung [HPES]

Version of module description: Gültig ab winterterm 2022/23

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written exam (60 minutes, open book, allowed tools: notes, print medias (books, printed slides...), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

Furthermore, they prove that they can design a water power station in concept and dimensioning as well as the state-of-the-art technologies for energy storage.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Bachelor's level knowledge in hydraulic engineering, e.g.

- "Basic Module Hydraulic and Water Resources Engineering"
- "Supplementary Module Hydraulic and Water Resources Engineering"

#### Content:

The module provides in-depth knowledge of principles, methods and technologies for calculation and management of sustainable generation of energy from hydropower.

- types of hydro power stations, specific requirements of large and small hydro power
- elements of hydro power installations
- hydro turbines: turbine types, application ranges
- stream turbines: fundamentals, turbine types, application range
- energy conversion in hydro turbines - physical fundamentals

- planning of hydro power stations: hydrological surveys, layout, power plan
- needs and requirements for energy storage
- fundamental options for power storage
- properties of storage technologies, pros and cons, application ranges, potential, development state, project examples
- pumped storage plants: fundamentals, electromechanical equipment, new approaches

**Intended Learning Outcomes:**

After successful participation in the module, students will be able

- to describe, identify and assess established and newly proposed technologies of hydropower and energy storage
- to explain and assess the physical foundations of the energy conversion as well as the fundamental approach in planning hydropower projects
- to evaluate hydropower project plans and to perform planning themselves.

**Teaching and Learning Methods:**

- lecture style
- practical examples
- coordinated moodle tests (voluntary)

**Media:**

- PowerPoint presentations with film sequences and computer animations
- blackboard exercises
- moodle tests (voluntary)
- lecture notes in moodle

**Reading List:**

See lecture notes

**Responsible for Module:**

Prof. Dr. Nils Rüther (nils.ruether@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydro Power and Energy Storage (Vorlesung, 2 SWS)

Reisenbüchler M [L], Reisenbüchler M, De Vos L, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV460018: Sustainable Water Resources Management | Modelle für eine nachhaltige Wasserbewirtschaftung [SWRM]

Version of module description: Gültig ab winterterm 2022/23

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written exam (60 minutes, open book, allowed tools: notes, print medias (books, printed slides...), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

The students will prove that they are able to apply modelling techniques in water management and to design the volumes and water levels of a reservoir.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Bachelor's level knowledge in hydraulic engineering, e.g.

- "Basic Module Hydraulic and Water Resources Engineering"
- "Supplementary Module Hydraulic and Water Resources Engineering"

#### Content:

The module provides in-depth knowledge of principles, methods and technologies for calculation and management of water resources.

- precipitation, runoff and runoff coefficient
- rainfall-runoff modelling
- flood routing
- flood statistics
- reservoir capacity
- storage plans and operation schemes
- flood retention

**Intended Learning Outcomes:**

After successful participation in the module, students will be able

- to apply important and mainly used modelling techniques and calculation methods of water management
- to assess their application areas and limitations
- to design a reservoir under the aspects of hydrology and water resources management.

**Teaching and Learning Methods:**

- lecture style
- practical examples
- coordinated moodle tests (voluntary)

**Media:**

- PowerPoint presentations with film sequences and computer animations
- blackboard exercises
- moodle tests (voluntary)
- lecture notes in moodle

**Reading List:**

see lecture notes

**Responsible for Module:**

Dr.-Ing. Richard Huber (richard.huber@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Sustainable Water Resources Management (Vorlesung, 2 SWS)

Huber R, Scherbaum S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV460019: Inland Navigation Management and Constructions | Verkehrswasserbau und Wasserstraßen

Version of module description: Gültig ab winterterm 2012/13

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam in this module is a written exam of 60 minutes in which the students have to answer questions in the field of inland navigation, both technical aspects and economic aspects, without additives in a given time. The comprehension of the topics contents is also stimulated by transfer questions, which are oriented on the presented exemplary areas of application.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bachelor degree in Civil- or Environmental Engineering

#### Content:

##### 1. Traffic system ship/waterway

- Transport economics, (transport volume, transport services, transport development)
- Waterways network (structure, classification, perspectives)

##### 2. Dynamic of inland waterway vessels

- Handling equipment for manoeuvring (propeller, rudder)
- Flow dynamics of the ship
- Fairway dimensions for single trip and oncoming traffic
- Cross-sectional geometry of the fairway

##### 3. Natural inland waterways

- River training measures (groynes, longitudinal training, bank protection)
- Management of bed-load transport

#### 4. Locks

- Types of locks
- Design principles
- Filling- and emptying systems
- Equipment of locks
- Maintenance management
- Entrance and exit basins of locks
- Examples for the extension of entrance and exit basins of locks

#### 5. Artificial inland waterways (canals)

- Historical canals (Canal du Midi, Ludwig-Donau-Main-Canal)
- Modern canals (standard cross-sections, stability of dams, watercrossing buildings)
- Example: waterway junction at Magdeburg (canal bridge, water-saving locks, ship lift)

#### 6. Environment protection, nature protection, preservation of the countryside

- Legal bases
- Taking into account regarding the maintenance of waterways (maintenance schemes, deposition of dredged material)
- Consideration for extension and new building measures (environmental impact assessments, assessments of impacts on the countryside)
- Requirements of the European Water Framework Directive
- Ecological fish migration facilities at impounded waterways

#### **Intended Learning Outcomes:**

After a successful participation in the module students are able to:

- understand the economic importance of waterways in inland areas with respect to transport capacity;
- analyse the principles on the hydraulic interaction between ship and waterway;
- comprehend the main construction types, operation and maintenance of natural and artificial waterways including aspects regarding environment protection, nature protection and preservation of the countryside.

#### **Teaching and Learning Methods:**

In order to complete the module successfully, the transfer of knowledge must be predominantly through practical examples. These examples of waterways from all over Germany can best be provided through a slide presentation. Where possible, video clips will be presented in order to visualize the complicated dynamics of inland ship transport. At the end of the module, a one-day excursion is offered in order to include in the transport hydraulic structures and construction sites.

#### **Media:**

PowerPoint presentation

**Reading List:**

Presentation slides as lecture script

**Responsible for Module:**

Franz Zunic (franz.zunic@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Verkehrswasserbau und Wasserstraßen (Vorlesung, 2 SWS)

Heinzelmann C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV500003: Unsaturated soil mechanics | Mechanik ungesättigter Böden

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Proof of performance takes place in the form of a 60 minute written exam.

The exam consists of general questions with unrestricted formulations. Aids including all lecture notes, literature and a basic academic calculator are allowed. It will be proven, that the students have developed an understanding for the conveyed fundamental relationships of unsaturated soil mechanics within the scope of the module. The focus of the answers lies on individual shorthand formulations. In part, small calculation problems must also be solved.

#### Repeat Examination:

#### (Recommended) Prerequisites:

The following modules should be passed: (Notice: The contents of the modules can be found in the respective module manuals (handbooks).)

- Foundation Engineering and Soil Mechanics Base & Supplementary Module (BV000019 and BV500006)
- Technical Mechanics I (BV000001)
- Technical Mechanics II (BV000004)
- Advanced Mathematics I (MA9517)
- Advanced Mathematics II (MA9512)

#### Content:

- Introduction to the principles of unsaturated soil mechanics
- total, matric and osmotic suctions
- determination of the suction tension-water content relationship of soils
- determination of hydraulic conductivity in unsaturated states
- models for the description of the suction tension-water content relationship
- models for the description of hydraulic conductivity

- description of water flow in unsaturated soils
- effective stresses in unsaturated soils
- volume change behaviour of unsaturated soils
- shear strength of unsaturated soils
- importance of unsaturated soil mechanics for design in geotechnical engineering

**Intended Learning Outcomes:**

After participating in the module the student is able to

- evaluate the soil-mechanical behaviour of unsaturated soils
- devise experimental investigations to be able to determine the soil-mechanical properties of unsaturated soils
- apply the basics of water flow in unsaturated soils
- use models to describe the stress propagation in unsaturated soils and shear strength of unsaturated soils
- evaluate geotechnical problems in unsaturated soils

**Teaching and Learning Methods:**

The lecture is intensively assisted by a PowerPoint presentation, whereby the students can directly profit from the experience of the lecturer. Films and pictures concerning experiments and procedures are integrated. It is possible to deepen the lecture material with the aid of voluntary exercise questions.

**Media:**

lecture notes, Powerpoint-presentation, blackboard, films

**Reading List:**

lecture notes

Lu, N. and Likos, W. J.: Unsaturated soil mechanics, Wiley Verlag, 2004

Fredlund, D. G. and Rahardjo, H.: Soil mechanics for unsaturated soils, Wiley Verlag, 1993

Mitchell, J. K. and Soga, K.: Fundamentals of soil behaviour, Wiley Verlag, 2005

**Responsible for Module:**

Dr.-Ing. Emanuel Birle, [emanuel.birle@tum.de](mailto:emanuel.birle@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Mechanik ungesättigter Böden (Vorlesung, 2 SWS)

Birle E, Bock B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV500004: Environmental Geotechnics II | Umweltgeotechnik II

Version of module description: Gültig ab summerterm 2019

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Proof of performance takes place in the form of a 60 minute written exam.

The exam consists of general questions with unrestricted formulations. Auxiliaries are not allowed. It will be proven, that the students have developed an understanding for the conveyed fundamental relationships of environmental geotechnics within the scope of the module. These include:

- Knowledge of recycling-construction materials and industrial by-products
- Resource efficiency during construction methods in geotechnics
- Characteristics of organic soils
- Characteristics of non-durable weak rocks

The focus of the answers lies on individual shorthand formulations. In part, small calculation problems must also be solved.

#### Repeat Examination:

#### (Recommended) Prerequisites:

The following modules should be passed: (Notice: The contents of the modules can be found in the respective module manuals (handbooks).)

- Foundation Engineering and Soil Mechanics Base & Supplementary Module (BV000019 and BV500006)
- Technical Mechanics I (BV000001)
- Technical Mechanics II (BV000004)
- Advanced Mathematics I (MA9517)
- Advanced Mathematics II (MA9512)
- Environmental Geotechnics for Civil Engineers (BV120002) or Environmental Geotechnics for Environmental Engineers (BV120050)



**Content:**

- Resource efficiency in geotechnics: Introduction, problem definition
- Non-durable weak rocks: Description, drum screen test, classification, grouping, installation
- Organic Soils: Classification, grouping, suitability
- Recycling-construction materials and industrial by-products: Classification, grouping, frost sensitivity, suitability
- Recycling-construction materials and industrial by-products: Mechanical soil improvement
- Pasty soft soils, slurries and suspensions: Dewatering processes
- Resource efficiency in underground engineering and tunneling: process-specific characteristics

**Intended Learning Outcomes:**

After participating in the module the student is able to

- apply a deepened knowledge concerning the handling of mineral waste and recycled construction materials.
- create a modern mass flow management for soil and other earthworks materials
- create suitability proof concepts for difficult earthworks materials
- evaluate complex relationships concerning the compaction of soils

**Teaching and Learning Methods:**

The lecture is intensively assisted by a PowerPoint presentation, whereby the students can directly profit from the experience of the lecturer. The PowerPoint-Slides are prepared for the students and are provided as print-outs in the lecture, as well as in digital form via the e-learning platform Moodle for follow-up purposes.

**Media:**

script, overhead-/powerpoint presentation, blackboard

**Reading List:**

lecture notes

lecture notes about Environmental Geotechnics for Civil/Environmental Engineers

VOGT, N. Skript "Studienunterlagen Grundbau und Bodenmechanik"

**Responsible for Module:**

Akad. Dir. Dr.-Ing. Dirk Heyer, [dirk.heyer@tum.de](mailto:dirk.heyer@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Umweltgeotechnik II (Vorlesung, 2 SWS)

Heyer D, Bock B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV520006: Transport Planning Master Module | Vertiefungsmodul Verkehrsplanung

Version of module description: Gültig ab summerterm 2012

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Achievement is recorded by a written 60-minute exam.

The purpose of the written test is to verify that the principal planning process of spatial planning and transport planning at different spatial scales as well as various methods for determining the transport demand and the associated problems were understood and can be concisely reproduced and applied.

Problems must be analyzed based on learning outcomes acquired in the course of the module, solutions must be found implemented in limited time.

The answers require partly own formulations, partly ticking specified multiple answers as well as short computing tasks.

In the exam no aids are allowed.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Grundmodul Verkehrstechnik/Verkehrsplanung

#### Content:

Verfahren der Planung:

- Theoretical planning basics: integration of different disciplines as well as different levels of scale in formal / informal processes
- Nationwide Strategic planning: Responsibilities of the EU / Federal / State, Federal Transport Infrastructure Plan
- Local formal planning: Spatial planning procedures, zoning, EIA / SEA
- Local and regional planning: zoning, regional governance

- Strategic transport planning at local level: transport development plan, air pollution control planning, noise abatement planning, traffic and mobility management
- Planning and financing instruments in public transport: Local public transport plans, standardized assessment

**Ermittlung der Verkehrsnachfrage:**

- introduction: travel demand estimation, travel demand management, travel demand modeling
- mobility behavior, spatial structures and transport
- classical methods / models of travel demand estimation
- application examples and exercises
- current research questions/modeling approaches, integrated land-use and transport modeling

**Intended Learning Outcomes:**

After participating in this module students will be able:

- to understand the interrelationships of the planning process
- to apply the formal planning process on the regional, local and local planning
- to evaluate the distinction between formal and informal processes
- to analyze and to evaluate the interrelationships of different disciplines and different levels of scale
- to evaluate classical travel demand models,
- to analyze system interactions and
- to apply and select modelling approaches for their own research questions.

**Teaching and Learning Methods:**

This event is a lecture supported by PowerPoint presentations. Presentations are provided to the students for comprehensibility as a handout. Also original planning documents are presented as examples. Furthermore guest lecturers are invited to illustrate projects and planning concepts from practice. Planning steps and processes including traffic impact studies and modelling applications are demonstrated by a study trip.

**Media:**

PowerPoint presentations, maps, plans, documents, handouts

**Reading List:**

Literature recommendations and links to web-based sources are given in the lecture.

**Responsible for Module:**

Wulfhorst, Gebhard; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Gebhard Wulfhorst (gebhard.wulfhorst@tum.de)

Roland Priester (roland.priester@tum.de)

Chenyi Ji (chenyi.ji@tum.de)

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV530014: Landslide Mapping Course | Hangbewegungskartierung

Version of module description: Gültig ab winterterm 2016/17

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>80   | <b>Contact Hours:</b><br>100         |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Prüfungsleistung setzt sich zu 50% aus einer Übungsleistung zur fünf-tägigen Hangbewegungskartierung im Gelände sowie zu 50% aus einer Projektarbeit zusammen, in der die Studierenden ein GIS-Projekt in digitaler Form bearbeiten.

Anhand der Übungsleistung sollen die Studierenden in Gruppenarbeit nachweisen, dass sie Werkzeuge, Methoden und Hintergrundwissen für eine Hangbewegungskartierung im Gelände zielgerichtet anwenden können. Die Gruppenarbeit ermöglicht die Bearbeitung größerer Kartiergebiete mit einer größeren Bandbreite an zu untersuchenden Prozessen. Die Charakterisierung und Analyse der identifizierten Hangbewegungen sowie eine Gefährdungsbewertung des betroffenen Hanges sollen schriftlich dokumentiert werden. Dabei sollen die Studierenden auch zeigen, dass sie fallspezifisch Gefahrenzonen, Alternativvorschläge zu geplanter Infrastruktur sowie Strategien zur Vermeidung, Vorhersage und Monitoring der Hangbewegung eruieren können.

Durch die Projektarbeit (GIS-Projekt) soll nachgewiesen werden, dass die Studierenden, mit Hilfe eines geographischen Informationssystems, eine konkrete ingenieurgeologische Fragestellung (z.B. Beurteilung der Standsicherheit) bewerten können. Sie weisen in mehreren Projektphasen nach, dass sie nicht nur Geodaten sammeln, analysieren, entwickeln und präsentieren können, sondern auch – wie in einer herkömmlichen geotechnischen Untersuchung - ein Produkt für einen hypothetischen Kunden entwickeln können. Zusätzlicher Bestandteil der Projektarbeit ist eine Präsentation, mit der die kommunikative Kompetenz bei der Darstellung von wissenschaftlichen Themen vor einer Zuhörerschaft überprüft wird. Die Projektarbeit wird in der gleichen Gruppenzusammensetzung wie die Übungsleistung ausgeführt, um die im Gelände gewonnenen Daten weiter zu verarbeiten.

#### Repeat Examination:

Next semester

**(Recommended) Prerequisites:**

- Kenntnisse und Fähigkeiten zu: geologischer Kartierung, Gebirgseigenschaften, Klassifikation von Boden und Fels, Gestein und Gebirge: Maßstabseffekte, Methoden der Ermittlung von Gesteins- und Gebirgskennwerten
- Bereits erfolgreich abgelegter GIS I Kurs

**Content:**

In the landslide mapping course one or several landslides are examined in field by the participants. The focus is put on the recognition and registration (mapping) of typical morphological features caused by landslides and their analysis for the determination of the landslide mechanism as basis for classification and further analysis using a Geographic Information System (GIS).

**Intended Learning Outcomes:**

- Die Gesteine im Gebiet beschreiben, klassifizieren und deren Beschaffenheit im Zusammenhang mit den Hangbewegungen vor Ort bewerten
- Die geologischen Strukturen und Einheiten im Gebiet erkennen und analysieren und eine geologische Karte des Gebiets entwickeln
- Selbstständig im Gelände Hangbewegungstypen und -prozesse erkennen, charakterisieren, klassifizieren, analysieren und bewerten (z. B. unter Berücksichtigung von geschätzter Mächtigkeit, Volumen, Bewegungsgeschwindigkeit, beeinflussten Bereichen, etc.)
- eine Gefährdungsbewertung der Hangbewegung durchführen (bezüglich Aktivität der Bewegung), inklusive Gefahrenzonierung, (Alternativ-)vorschläge zu geplanter Infrastruktur, Vermeidungsstrategien, Vorhersage- oder Monitoring-Strategien entwickeln
- Die Studierenden lernen die grundlegenden Eigenschaften und Möglichkeiten von Geoinformationssystemen kennen
- Erlernen und Verstehen von Digitalen Geländemodellen sowie geographischen und projizierten Koordinatensystemen und deren Anwendung bei der Erstellung der weiteren Karten
- Nutzung von externen Open-Source und privaten Geodaten erlernen, verstehen und für das eigene Projekt anwenden
- Eine strukturierte Systematik beim ingenieurgeologisch-geomorphologischen Kartieren kennen lernen, verstehen und insofern anwenden, als dass die Studierenden ein spezifisches System mit einer eigenen Klassifikation von z. B. Hangbewegungs-, Boden-, Gesteinstypen für die geologischen, geomorphologischen und phänomenologischen Karten in ihrem Projektgebiet entwickeln
- Die Studierenden verstehen wie die im Gelände kartierten Informationen in eine digitale Karte übertragen werden
- Verstehen wie man mit digitalen Geodaten arbeitet, diese aufbereitet und darstellt (inkl. Anwendung auf das eigene Projekt): sorgfältige Datenorganisation, Editieren von Geodaten, Anlegen von Geometrien, Styles, Attributierung, Symbole, Annotations, TOC, Layout
- Die Studierenden lernen und verstehen, wie Rasterdaten aufgebaut sind, Raster basierte Analysen funktionieren und wenden eine Standortanalyse auf ihr eigenes Kartiergebiet an

- Die Studierenden sind abschließend in der Lage, selbständig räumliche Abfragen und Analysen mit Geodaten anzuwenden
- komplexe Kartierprojekte mit ESRI ArcGIS® oder vergleichbaren Geoinformationssystemen wie z. B. QGIS durchführen und druckreife Karten entwickeln

### **Teaching and Learning Methods:**

Bestandteil der Hangbewegungskartierung ist ein fünf-tägiger Gelände-Blockkurs. Am ersten Tag der Geländeübung findet eine Einführungs-exkursion statt, in der die Studierenden mit den lokalen Besonderheiten von Geologie, Gesteinen sowie Hangbewegungen vor Ort vertraut gemacht werden. Ihnen werden praktische Kartierungsmethoden und Herangehensweisen gezeigt (Best-practice-Beispiele für das Interpretieren von Hangbewegungsformen oder -prozessen). Außerdem wiederholen die Studierenden das Beschreiben von Gesteinen, Fels und Boden im Gelände. In den darauffolgenden Tagen werden die TeilnehmerInnen in Kleingruppen selbstständig die Geologie und Hangbewegungen im Gelände kartieren. Die Betreuenden werden in dieser Zeit die einzelnen Gruppen mehrmals aufsuchen, um sie zu unterstützen und Fragen zu klären. Auf diese Art und Weise können die zu übermittelnden Lernergebnisse am besten näher gebracht werden.

Die TeilnehmerInnen des GIS-Kurses werden in Gruppen á 3-4 Studierenden eingeteilt. Innerhalb dieser Gruppen bearbeiten sie ein Projekt mit Hangbewegungs-Abschätzung für einen imaginären Auftraggeber mithilfe der GIS-Softwares ESRI ArcGIS oder QGIS. In jeder Gruppe gibt es jeweils eine/n Verantwortliche/n für die Themenbereiche Geologie, Geomorphologie, Hangprozesse sowie gegebenenfalls eine Zusammenfassung aller Teilkomponenten.

Die Lehrinhalte werden zunächst theoretisch unter Zuhilfenahme von Präsentationen behandelt (1 Stunde) und dann direkt am Computer praktisch umgesetzt (2 Stunden). Da der Kurs in einem EDV Raum stattfindet, haben die Studenten die Möglichkeit die Übungsbeispiele parallel zum Dozenten durchzuführen. Anschließend werden die Lerninhalte Abschnittsweise nochmals in kurzen selbständigen Übungen vertieft.

### **Media:**

Hangbewegungskartierung: Präsentation, Exkursion, Gesteinsproben, Handouts mit den wichtigsten Diagrammen und Tabellen, Kartierarbeit in Kleingruppen

GIS-Kurs: PPT-Präsentation, Tafelanschrift, Videos, Handouts mit den wichtigsten Diagrammen und

Tabellen, Übungen und Projektarbeit am PC in Gruppen

### **Reading List:**

**Responsible for Module:**

Prof. M. Krautblatter, Fachgebiet für Hangbewegungen Lehrveranstaltungen (Lehrform, SWS)

Dozent(in): Hangbewegungskartierung: Exkursion, Geländeübung 2,8 SWS GIS-Kurs: Übung und Vorlesung, 3 SWS

**Courses (Type of course, Weekly hours per semester), Instructor:**

Lehrveranstaltungen (Lehrform, SWS) Dozent(in):

Hangbewegungskartierung: Exkursion, Geländeübung 2,8 SWS

GIS-Kurs: Übung und Vorlesung, 3 SWS

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### **BV530023: Study Project "Prevention against Alpine Natural Hazards" | Modellprojekt "Prävention gegen alpine Naturgefahren"**

Version of module description: Gültig ab summerterm 2018

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>90          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The course takes place in the form of a project work. The students become acquainted with the assigned task together or in smaller groups and work on them. The project results are documented in the form of a written project report and will be presented to the lecturers within a final presentation. The students prove their learning results, by compiling the project report and by generating the technical project results (after completion of the project the students are in a position: to plan and perform (small) measurement campaigns independently, to independently carry out the necessary resource planning, to analyze and use existing datasets and to update them if needed, to do and evaluate planning activities within external constraints, to interact with decision-makers, experts and citizens on site and to present the results of the project). The results of the project documented in the project report are used for grading. Individually assessable contributions may be: teamwork, problem solving skills, scientific mode of work, methodological competences, presentation skills.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Required are fundamentals in engineering geodesy, GIS and land regulations & land management. These fundamentals can be achieved e.g. through the successful completion of the Bachelor's degree course "Geodesy and Geoinformation". The project explicitly addresses alpine natural hazards. Surefootedness in the alpine terrain is therefore essential for some project tasks; but there is also the possibility of alternative project tasks.

#### **Content:**

Design and analysis of GNSS- and terrestrial measurement networks for deformation analysis of instable alpine rock masses; use of modern instruments (Smart Pole / Smart Station) for

effective survey of objects in hardly accessible areas; use of terrestrial laserscanners for capacity measurements of potentially dangerous rock masses; combining various data from different sources in a single GIS for extensive documentation and modeling of local spatial natural hazards; Evaluation of possible hazard scenarios using existing data in GIS; Development of sustainable, environment-friendly and socially accepted procedures to prevent lives and goods in populated areas using planning and land regulatory methods; Development of use concepts for the threatened regions in context of tourism, geology and environment; Combination of the mentioned module parts by adequate data acquisition on-site; Collaboration with local authorities (Austrian torrent and avalanche control, municipality, Tyrolean government) and experts (geologists).

### **Intended Learning Outcomes:**

After completion of the project the students are in a position: to plan and perform (small) measurement campaigns independently, to independently carry out the necessary resource planning, to analyze and use existing datasets and to update them if needed, to do and evaluate planning activities within external constraints, to interact with decision-makers, experts and citizens on site and to present the results of the project.

### **Teaching and Learning Methods:**

Design and analysis of GNSS- and terrestrial measurement networks for deformation analysis of instable alpine rock masses; use of modern instruments (Smart Pole / Smart Station) for effective survey of objects in hardly accessible areas; use of terrestrial laserscanners for capacity measurements of potentially dangerous rock masses; combining various data from different sources in a single GIS for extensive documentation and modeling of local spatial natural hazards; Evaluation of possible hazard scenarios using existing data in GIS; Development of sustainable, environment-friendly and socially accepted procedures to prevent lives and goods in populated areas using planning and land regulatory methods; Development of use concepts for the threatened regions in context of tourism, geology and environment; Combination of the mentioned module parts by adequate data acquisition on-site; Collaboration with local authorities (Austrian torrent and avalanche control, municipality, Tyrolean government) and experts (geologists).

### **Media:**

scripts, datapool, expert interviews

### **Reading List:**

- F. Rudolf-Miklau: Naturgefahren-Management in Österreich
- R. Marschallinger u.a.: Geostatische Raum-Zeit-Analyse der Deformationen am Hornbergl, Proceedings COGeo 2010
- J. Glabsch u.a.: Monitoring the Hornbergl landslide[&], Journal of Applied Geodesy 4/2009

### **Responsible for Module:**

Prof. Dr.-Ing. habil. Thomas Wunderlich, [th.wunderlich@tum.de](mailto:th.wunderlich@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modellprojekt „Prävention gegen alpine Naturgefahren“ (Übung, 6 SWS)

Donaubauer A, Holst C, Kolbe T, Kutzner T, Raffl L, Weinhuber A, Wiedemann W

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV560005: Intelligent Vehicles | Intelligente Fahrzeuge [IV]

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module is completed with a written exam of 60 minutes. It is allowed to use a self-composed hand-written sheet of DIN A4 paper (front and back side). The students prove through theoretical questions they have understood in entirety the aspects of the intelligent, communicating vehicle in connected traffic presented by the lecturers and furthermore can differentiate the technical principles and components of the overall system in a simple reproducing way.

#### Repeat Examination:

#### (Recommended) Prerequisites:

-

#### Content:

Basics: Introduction to and definition of Automatic Driving Assistance System, Intelligent Transport Systems (ITS) and Cooperative Systems in Transport, impact on transport system and driver (comfort, active safety, efficiency...), driver-environment interaction

- ADAS Functions: Classifications of ADAS functions, automatic control engineering, autonomous driving
- Sensor technology: Detection, data fusion, radar, video etc
- MMI: Man-machine interaction, display and operation concepts, psychology of perception, driving simulator
- Navigation: Coordinate systems for navigation, map matching, positioning, route planning, guidance
- Ensuring of ADAS: Ensuring functions of ADAS concepts, assessment of functions, legal aspects
- ADAS, insights into practical applications: coordination of passive and active safety, accident research

**Intended Learning Outcomes:**

At the end of the module students can:

- Remember the current trends in the automobile industry as to development of connected and (partially) automated vehicles
- Differentiate vehicle sensors needed in such driving tasks
- Denominate the state of the art in human-machine-interfacing in the field of driver assistance systems
- Assign possibilities of GPS-based and sensor-based navigation
- Characterize the employment of driver assistance systems in safety-critical and legal contexts

**Teaching and Learning Methods:**

The course consists mostly of talks. For some of the topics, external experts are invited to present the state of the art. The talks are backed up by presentations which will be available online or are handed out to the students.

**Media:**

Presentations

**Reading List:**

Bishop (2005): Intelligent Vehicle Technology and Trends, Artech House, London"

**Responsible for Module:**

Bogenberger, Klaus; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV560011: Governance | Governance

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Students will be graded based on a scientific seminar paper and a presentation.

The goal of the term paper is to test students understanding of a set of key concepts concerning governance, as well as to test them on their ability to apply a governance approach independently to a case study and to develop insights that are relevant to practitioners and/or the expert community and academia.

Students will conduct research on and write the term paper independently of the seminar. They will be expected to structure the paper in terms of a social science academic paper, that is with a relevant problem statement, question or key argument, brief state-of-the-art, methodology (including analytical approach), case study and analysis, key findings and insights (theoretical and practical) for a specified audience.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Vorkenntnisse in Verkehrsplanung und Verkehrspolitik

#### Content:

Transport planning is much more than paper work. It is working with people, institutions, companies and so forth. It is also about bargaining and negotiating on better and more effective solutions for transport problems. The paths to sustainable transport demand management on the regional level go along with new concepts of power management and government. Governance is one of the major catchwords to describe the fundamental changes in the relations of political, economic and civil society actors in cities and regions.

Four central topics will shape the lectures and discussions in the class this semester. All topics are closely related to the planning and politics of transport and mobility in cities:

- What is governance? An introduction to the governance debate

- Who's in charge? The changing role of the state
- Who decides? Politics, democracy and the public
- How to decide? Consultation, participation and expertise

### **Intended Learning Outcomes:**

After attending the module, students are able to identify and actively communicate and apply key concepts of governance to current debates and issues in the transport sector.

They will be aware of the range of concepts and theoretical approaches concerning the topic of governance, including, but not limited to: the changing role of the state in the transport sector; key actors in governance; issues like democracy, accountability and legitimacy in governance; the role of the public and expert opinion; and different types (e.g. hierarchical, communities, networks, market, etc.) and processes (e.g. collaborative, technocratic, grassroots, etc.) of governance present in everyday planning and policy in the transport sector.

Further, they will be able to analyze actual policy problems and case studies using a governance perspective and to formulate relevant insights.

### **Teaching and Learning Methods:**

The course is an active mix of lecture, discussion, student presentation, in- and out-of-class activities and readings, in order to facilitate a proper learning of governance theories alongside their application in the analysis of everyday processes of policy-making and planning.

The lectures will be supported with traditional PowerPoint presentations, the blackboard and other materials when necessary.

Discussion will take place in a "round table setting", bringing in the interests and issues students are faced with in their studies, project-work and professional life.

Student presentations will be organized in groups of 2-3 students, and based on readings and related topics from the module. Each student will present once.

In- and out-of-class activities will be based on the application of governance themes and approaches to real-life situations and other case studies.

In addition, students will be asked to read a set of relevant theoretical and practical articles on governance in the transport sector before attending lectures and student presentations.

### **Media:**

Reader, PowerPoint presentations, material for in-class activities, blackboard.

### **Reading List:**

Bang, H.P. (Ed.), 2003. Governance as Social and Political Communication. Manchester University Press, Manchester.

Bevir, M., 2009. Key Concepts in Governance. SAGE Publications Ltd.

Fischer, F., 2009. Democracy and expertise: Reorienting policy inquiry. Oxford University Press, Oxford.

Henderson, J., 2013. Street fight: the politics of mobility in San Francisco. University of Massachusetts Press, Amherst.

Geels, F., Kemp, R., Dudley, G., Lyons, G. (Eds.), 2012. Automobility in transition?: A socio-technical analysis of sustainable transport. Routledge, London.

Meadowcroft, J., 2007. Who is in Charge here? Governance for Sustainable Development in a Complex World. *Journal of Environmental Policy & Planning* 9, 299–314.

Newman, J. (Ed.), 2005. *Remaking governance: peoples, politics and the public sphere*. Policy Press, Bristol.

Peters, B.G., 2011. Governance as political theory. *Critical Policy Studies* 5, 63–72.

Pierre, J., Peters, G.B., 2000. *Governance, politics and the state*. Macmillan Press Ltd., Hampshire.

Wagenaar, H., 2011. *Meaning in action?: interpretation and dialogue in policy analysis*. Sharpe, Armonk, NY.

**Responsible for Module:**

Wulfhorst, Gebhard; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Governance (Vorlesung, 3 SWS)

Scotellaro L [L], Scotellaro L, Zimmer C ( Scotellaro L )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV560024: Traffic Management | Verkehrsmanagement [TM]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The evaluation includes a written examination of 120 minutes, in which the student should demonstrate an ability to independently identify the problem in a given amount of time and reach a solution without the use of aid materials. The test consists of factual and understanding questions that cover the entire lecture material and all the exercises, but focus mainly on the material covered in the tutorials. All questions must be completed without the use of aid materials. The students apply their acquired basic knowledge about the theory of traffic flow and traffic control. A formula sheet containing the necessary formulas discussed in the lecture and tutorial will be provided for the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in traffic engineering, traffic control and transportation planning e.g. Traffic Engineering and Transport Planning-Basic Module and Traffic Engineering and Transport Planning-Supplementary Module

#### Content:

The compulsory course consists of two courses. The lecture will be supported by practical exercises whenever possible, in which students will apply taught skills and methods to solve problems independently. The four lecture parts contain the following content:

##### Course 1: Traffic Flow Theory

- Introduction to traffic flow (Variables of traffic flow, measurement principles, time-space diagrams, stochastic distributions)
- Cross-sectional data (local vs momentary mean speed, fundamental diagram, cumulative plots)

- Spatio-temporal traffic dynamics on motorways and in urban areas (Contour plots, congestion formation and classification, empirical data, macroscopic fundamental diagram, urban congestion)
- Macroscopic traffic flow models & Cellular Automaton (Continuum theory & Lighthill-Whitham-Richards, Shock waves, Cell Transmission Model, Cellular Automaton)
- Microscopic traffic models, and models for pedestrians and bicyclists (Car-following, lane changing, social force model)
- Delay and origin-destination estimation (Queuing theory fundamentals, deterministic models, stochastic models, van zuylen estimation, furness procedure)

#### Course 2: Traffic Control - Basics

- Introduction to navigation systems and routing algorithms
- Quality assessment of dynamic traffic information
- Introduction to control theory
- Traffic management on motorways
- Urban Traffic Control
- Public Transport Control, Passenger Information
- Parking management systems
- Congestion pricing

#### Intended Learning Outcomes:

At the end of the course traffic flow theory students are able to

- understand the basic concepts of and the theory behind traffic flow
- evaluate the quality of traffic flow on highways and in urban cities.
- understand the variety of modelling approaches for traffic flow.
- apply the most important macroscopic and microscopic traffic flow models, delay models, and models to estimate origin-destination relations at the intersection level.

At the end of the course traffic control basics students will learn

- the basics concepts of control theory and traffic management in motorways and urban roads
- different routing algorithms and navigation concepts in road networks
- quality assessment concepts for evaluation of dynamic traffic information
- the fundamentals of control theory in traffic engineering
- design and evaluate traffic signal operation at isolated intersections and traffic signal coordination along arterial "green wave"
- main principles of traffic management systems in motorways such as ramp metering
- the role of ITS in the operation of public transport systems
- fundamentals of parking management systems and congestion pricing schemes for cities

At the end of the course, the students will have an understanding of the transportation systems in Germany. They know and understand the specific aspects influencing today's transportation system. The students are able to apply this knowledge to their specific academic fields of interest.

#### Teaching and Learning Methods:

The module consists of lectures and accompanying tutorials. In addition, an excursion will be organized that supports the topics covered in the course. The regular lectures will be

supplemented by guest lectures given by external experts working in the field. The lectures are given with presentations. In the tutorials, the instructor will use a portion of the time to solve examples for the students, and students will have the remainder of the tutorial time to solve problems individually.

**Media:**

Powerpoint presentations, exercise assignments, films, excursion

**Reading List:**

Bogenberger, Bertini, Boice [2006] Analytische Methoden zur Interpretation von Verkehrsdaten, Straßenverkehrstechnik

Brilon W, Geistefeldt J, Regler M [2005] Reliability of freeway traffic flow: a stochastic concept of capacity.

Karl, Kessler, Bogenberger [2019] automated classification of different congestion types

Knoop, V [2018] Introduction to Traffic Flow Theory

Treiber & Kesting [2013] Traffic Flow Dynamics - Data, Models and Simulation

Daganzo, C [1997] Fundamentals of Transportation and Traffic Operations

Rempe, Huber, Bogenberger (2016) Spatio-temporal congestion patterns in urban traffic.

Transportation Research Procedia

Geroliminis, Zheng, Ampountolas (2014) A three-dimensional macroscopic fundamental diagram for mixed bi-modal urban networks. Transportation Research Part C

Geroliminis & Daganzo (2008) Existence of urban-scale macroscopic fundamental diagrams: Some experimental findings. Transportation Research Part B

Tilg, Amini, & Busch (2020) Evaluation of analytical approximation methods for the macroscopic fundamental diagram. Transportation Research Part C

Loder, Ambühl, Menendez, Axhausen (2019) Understanding traffic capacity of urban networks. Scientific Reports 9

Helbing, D., & Molnar, P. (1995). Social force model for pedestrian dynamics. Physical review E

Gipps, P.G. [1981]: A behavioural car-following model for computer simulation

Herz, R.; Schlichter, H.; Siegener, W. [1992]: Angewandte Statistik für Verkehrs- und Regionalplaner

Webster, F. V. (1958). Traffic signal settings, road research technical paper no. 39. Road Research Laboratory.

Willumsen, L. G. (1978). Estimation of an OD Matrix from Traffic Counts—A Review.

Van Zuylen, H. J., & Willumsen, L. G. (1980). The most likely trip matrix estimated from traffic counts. Transportation Research Part B: Methodological

Van Zuylen, H. J. (1981). Some improvements in the estimation of an OD matrix from traffic counts.

Highway Research Board [2000]: Highway Capacity Manual

Kerner, B. S. [2004]: The Physics of Traffic

Kotsialos, A.; Papageorgiou, M.; Mangeas, M.; Haj-Salem, H. [2000]: Coordinated and integrated control of motorway networks via non-linear optimal control

Lighthill, M. J.; Whitham, G. B. [1955]: On Kinematic Waves. II. A Theory of Traffic Flow on Long Crowded Roads

Leutzbach, W. [1988]: Einführung in die Theorie des Verkehrsflusses

Nagel, K.; Schreckenberg, M. [1992]: A cellular automaton model for freeway traffic.

Orcutt, F. L. [1993]: The Traffic Signal Book

Papageorgiou, M. [2000]: Regelungsstrategien für den Straßenverkehr - Vergangenheit, Gegenwart und Zukunft

Piszczyk, S.; Dinkel, A.; Leonhardt, A.; Mutzbauer, J. (2007): Testfeld für die Erfassung von Umfelddaten in Streckenbeeinflussungsanlagen

Schnabel, W.; Lohse, D. [1997]: Grundlagen der Straßenverkehrstechnik und der Verkehrsplanung Band 1 & 2

Wang, Y.; Papageorgiou, M. [2005]: Real-time traffic state estimation based on extended kalman filter. A general approach.

Wardrop, J. G. [1952]: Some theoretical aspects of road traffic research

Wiedemann, R. [1974]: Simulation des Straßenverkehrs

**Responsible for Module:**

Tilg, Gabriel M.Sc.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Grundlagen der Verkehrssteuerung (Vorlesung mit integrierten Übungen, 2 SWS)

Bogenberger K [L], Bogenberger K ( Amini S, Sautter N ), Spangler M ( Amini S, Sautter N )

Verkehrsflusstheorie (Vorlesung mit integrierten Übungen, 2 SWS)

Bogenberger K [L], Bogenberger K ( Rostami Shahrabaki M, Tilg G ), Spangler M ( Rostami Shahrabaki M, Tilg G )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV580008: Modelling of Environmental Effects in Transportation | Modellieren von Umweltwirkungen im Verkehr [MoDEET]**

*Modelling of environmental effects in transportation*

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105   | <b>Contact Hours:</b><br>75                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination consists of a written, closed book test of 60 minutes duration and a scientific paper with presentation. The exam consists of theoretical questions; aids are not allowed. The scientific paper will be submitted in written form and presented during the seminar. The weighting of the two examination elements in the final score is 1:1.

In the written exam, the students answer theoretical questions of understanding and show that they know the most important environmental impacts of transport, their respective limits and norms. They prove their ability to critically analyze the relationships between traffic and emissions. Through the scientific paper, the students prove their ability to independently design and process more complex, spatial tasks in emission estimation and modelling using a self-developed emission model with selected data. The presentation of the paper demonstrates their ability to present the own analyzes and impact assessments of emission-reducing measures comprehensibly and precisely, and that they are able to discuss their results convincingly and professionally with an audience of experts.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

-

#### **Content:**

'Part 1: Transport and the Environment (Lecture):

- Transport and Air Pollution
- Vehicle Emissions Standards

- Noise
- Consumption of energy
- Climate change
- Sustainable transport

**Part 2: Modelling of Transport Related Emissions (Seminar):**

- Emission inventories and emission balances
- Emission factor models
- Transport activity data collection
- Data analysis and interpretation
- Emission estimation of transport activities
- Emission scenarios (BAU and mitigation)
- Evaluation of emission reduction strategies

**Intended Learning Outcomes:**

'After the completion of the module, students are able to:

- know the main environmental effects of traffic
- understand the main traffic related emissions, their sources and their health impacts
- know the common emission standards for vehicles and their measurement
- know the relation of sound and noise as well as the health impact of noise
- know the cause and impact of transport on global climate change
- know definitions and measures for (a) sustainable transport systems
- understand the use and development of emission inventories
- know and apply methods for estimating transport related emissions
- develop emission models and acquire the necessary data
- develop strategies for emission reduction and evaluate those strategies by the means of models
- present the results of their estimations in written and oral form

**Teaching and Learning Methods:**

The module consists of 2 lectures. The theoretical basis on emissions and their interrelationships with transport are presented in a series of lectures. Additional materials such as images and films are used to better illustrate the input. In seminar work extends the theoretical foundations with practical examples that are transferred into models for emission assessment. Discussions on strategic concepts for emissions reduction in cities deepen the conceptual approach of environmental related tasks in transportation. Different modeling approaches and case studies are elaborated and critically evaluated during the seminar and the personal home work of the students.

**Media:**

presentations, blackboard

**Reading List:**

- CO2 Emissions from fuel combustion. Highlights. International Energy Agency 2011
- Energy technology perspectives. Scenarios and strategies in 2050. International Energy Agency 2010

- CO<sub>2</sub>-Emissionsminderung im Verkehr in Deutschland. Mögliche Maßnahmen und ihre Minderungspotentiale. Ein Sachstandsbericht des Umweltbundesamtes. Umweltbundesamt 2010.
- Fortschreibung und Erweiterung "Daten- und Rechenmodell: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2030 (TREMOT, Version 5). IFEU 2010
- Air Quality Management. Sustainable Transport: a sourcebook for policy-makers in Developing cities, Module 5a, revised April 2004, GTZ GmbH;
- Reducing Air Pollution from Urban Transport Companion. Ken Gwilliam, Masami Kojima, June 2005,
- THE WORLD BANK; Air Quality Guidelines Global Update 2005. World Health Organization 2006, ISBN 9289021926

**Responsible for Module:**

Wulfhorst, Gebhard; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Verkehr und Umwelt (Vorlesung, 2 SWS)

Bogenberger K [L], Tsakarestos A ( Bachmann F, Ilic M )

Modellieren von Umweltwirkungen im Verkehr (Vorlesung, 3 SWS)

Wulfhorst G ( Seisenberger S ), Ilic M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV580010: Analysis Methods - Statistics and GIS | Analysemethoden - Statistik und GIS**

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

This module is no longer offered.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

#### **Content:**

#### **Intended Learning Outcomes:**

#### **Teaching and Learning Methods:**

#### **Media:**

#### **Reading List:**

#### **Responsible for Module:**

Antoniou, Constantinos; Prof. Dr.



**Courses (Type of course, Weekly hours per semester), Instructor:**

Geo-Information (Vorlesung mit integrierten Übungen, 4 SWS)

Meng L, Murphy C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV600004: Structural Reliability | Zuverlässigkeitstheorie

Version of module description: Gültig ab winterterm 2011/12

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Prüfungsdauer (in min.): 30.

Oral examination Students will be given one problem, which they should study for 15min and outline a solution. This will be followed by additional follow-up questions.

#### Repeat Examination:

Next semester / End of Semester

#### (Recommended) Prerequisites:

The course will assume a basic knowledge of probability concepts such as random variables and their description (e.g., through completion of the BSc course Zuverlässigkeit and MSc course Risk Analysis I). Basic Matlab knowledge is an advantage.

#### Content:

1. Introduction and brief review of basic probability theory
2. First Order Reliability Method
3. Risk acceptance and target reliabilities
4. System reliability
5. Monte Carlo Simulation
6. Importance sampling
7. Subset simulation
8. Response surface methods (metamodels) and coupling with FEM codes
9. Random variable elimination
10. Time variant reliability analysis
11. Final project

**Intended Learning Outcomes:**

This course enables the student to perform reliability analysis for realistic engineered structures and systems, and to interpret the results of such analyses. At the end of the course, the student will be able to:

- Formulate the reliability problem for realistic structures.
- Establish the probabilistic model for various loadings and materials.
- Compute estimates of the failure probability of engineered systems using various approximate methods.
- Construct response surfaces for the reliability analysis of systems that are analyzed with large FEM codes.
- Assess the relative importance of random variables.
- Assess the sensitivities of the results to model assumptions.
- Update the reliability estimates with observed data.
- Perform reliability-based optimization of engineered systems

**Teaching and Learning Methods:**

The course will consist of lectures (50%) and numerical calculations (50%). Exercises will be performed partly using general-purpose and specialized computer software.

**Media:**

- lectures with blackboard supported by Powerpoint
- exercises in the computer lab using Matlab and Strurel software
- lecture notes including theory and examples
- homework examples

**Reading List:**

Lecture notes will be distributed. The following books provide useful supplemental material:

- Melchers R. (1999). Structural Reliability Analysis and Prediction. 2nd edition, John Wiley & Sons, New York
- Ditlevsen, O., and H. O. Madsen (1996), Structural Reliability Methods, John Wiley & Sons.

**Responsible for Module:**

Daniel Straub (straub@era.bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Structural Reliability (Seminar, 2 SWS)

Straub D [L], Kamariotis A, Papaioannou I, Straub D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV600011: Engineering Data Analysis with Matlab | Datenanalyse für IngenieurInnen mit Matlab

Version of module description: Gültig ab summerterm 2013

|                                  |                             |                                  |                                      |
|----------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>2            | <b>Total Hours:</b><br>60   | <b>Self-study Hours:</b><br>40   | <b>Contact Hours:</b><br>20          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Project work: The students will work in small groups on a 6 week project, where they will apply the methods learned during the course. The problem the students will have to solve is closely related to the exercises given throughout the semester. It will involve mainly basic statistical data analysis based on the software tool Matlab. The students will have to organize the team and hereby practice and apply soft skills required for team work. The project must result in a Matlab code and a written report which is graded.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge of probability concepts such as random variables and their description (e.g., through completion of the BSc course Zuverlässigkeit und Lastannahmen or Einführung in das Risikomanagement) is of advantage, but not required.

#### Content:

This course is designed to make students familiar with Matlab and its application for the analysis of data.

1. Statistics of data sets
2. Graphical representation of data sets
3. Statistics of pairs of data sets
4. Simulation of random variables

#### Intended Learning Outcomes:

This course is designed to make students familiar with Matlab and its application for the analysis of data. At the end of the course, students will be able to:

- Perform data analysis (statistics) using Matlab
- Interpret the information hidden in data sets
- Simulate random variables using Matlab

**Teaching and Learning Methods:**

The course will consist of 4 weeks of weekly lectures (2 hours) and exercises (2 hours). The lectures will be given with PowerPoint presentations and examples will be shown in Matlab. The students will subsequently solve practical exercises in Matlab together with the help of supervising tutors. The lecture notes in PDF form will be distributed at the beginning of the semester.

**Media:**

- lectures with Powerpoint presentations
- excercises using Matlab supervised by tutors
- lecture notes including theory and examples

**Reading List:**

Lecture notes will be distributed. The following books provide useful supplemental material:

- Ang, A. H.-S., and Tang, W. H. (2006). Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering, Wiley, New York.
- <http://www.mathworks.de/help/techdoc/>

**Responsible for Module:**

Daniel Straub (straub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV610020: Computer Aided Traffic Engineering with Matlab | Computerunterstützte Verkehrsplanung mit Matlab

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Written exam (60 min); closed book and no additional utilities. In case of small number of participants the exam is performed as oral exam.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basics in programming or computer science are useful

#### Content:

Usage of Matlab as programming tool in the special context of transportation systems. Students should also learn basic methods in software development.

#### Intended Learning Outcomes:

Students are able to

- Use the Matlab software development tool interactively and in combination with scripts
- Code mathematical formulas and calculations efficiently with scripts and functions
- Read data files, process and evaluate them

- Create graphs and figures
- Evaluate results and interpret them
- Handle error sources

**Teaching and Learning Methods:**

The lecture is split into theoretical and practical units, which help to learn the basics of Matlab. The basics are applied in a project by processing, analyzing and interpreting real data from traffic engineering. The students must organize themselves, but get the necessary hints and information. Goal is the successful solution of a real task using the learned skills.

**Media:**

The theory part consists of powerpoint presentations, which are also offered to the students. They are extended with exercise sheets with solutions for the lessons and for the private studies. The practical part consists of code snippets and examples.

**Reading List:**

Script (related literature is referenced there)

**Responsible for Module:**

Alexander Neidhardt (alexander.neidhardt@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Computer Aided Traffic Engineering with Matlab (TS) (Vorlesung, 1 SWS)

Neidhardt A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV620006: Special Topics in Sustainable Design | Sonderthemen des nachhaltigen Bauens

Version of module description: Gültig ab winterterm 2018/19

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Lecture with preparation and follow-up of the lecture contents. Independent development of strategies and approaches to solutions, which are presented at the end of the semester in the form of a scientific paper and a presentation. The examination in the form of a presentation and a scientific paper is intended to demonstrate that students are able to deal with current research topics over a period of one semester and to critically examine them. In the process, various questions from the fields of building physics, architecture and technical building equipment are addressed and applied and evaluated in a research-related manner.

In interaction with the examiners, typical problems are to be analysed in a result-oriented way and the possible solutions are to be brought into a meaningful context.

The form of the oral assessment allows for iterative questions of increasing complexity and the individual approach to the students, which enables a realistic assessment of the competences acquired in the module.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Grundkenntnisse in der Architektur/Bauphysik/Gebäudetechnik

#### Content:

As drivers of science and research, universities are continually expanding their ties with the business world. The ring lectures, which take place at regular intervals, give students insight into practical work experience. The lecturers will both share experience from their companies and be available for discussions on topics from the public sector and other fields of research. In collaboration with the Oskar von Miller Forum.



**Intended Learning Outcomes:**

Connect students to current issues from the real world. Provide insight into topical discussions from a group of themes and establish contact with companies.

**Teaching and Learning Methods:**

The course takes the form of a classic lecture, followed by discussions between the students and experts from research and business. Students participating in the lecture select one topic/object each from the following teaching content at the beginning of the semester, which is to be researched intensively throughout the semester. At the end of the semester, the result is outlined in a short presentation.

**Media:**

lecture notes, data projector presentation

**Reading List:**

Hegger, Manfred ; Fuchs, Matthias ; Stark, Thomas ; Zeumer, Martin: Energie Atlas : Nachhaltige Architektur. Berlin: Walter de Gruyter, 2007.

Kaltschmitt, Martin ; Streicher, Wolfgang ; Wiese, Andreas: Erneuerbare Energien : Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Berlin Heidelberg New York: Springer-Verlag, 2013.

Lenz, Bernhard ; Schreiber, Jürgen ; Stark, Thomas: Nachhaltige Gebäudetechnik : Grundlagen - Systeme - Konzepte. Berlin: Walter de Gruyter, 2010.

**Responsible for Module:**

Prof. Werner Lang sekretariat.enpb.bgu@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV620020: Case Studies of Sustainable Urban Developments and Infrastructure | Fallstudien nachhaltiger Quartiers-, Stadt- und Infrastrukturentwicklungen**

Version of module description: Gültig ab winterterm 2011/12

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Successful participation in the lecture and supervised preparation of a seminar paper on the topics covered in the lectures. In addition, there will be excursions to selected buildings, urban neighborhoods and infrastructure constructions. Moreover, guest lecturers will contribute to the lecture to demonstrate links to practical work and applications. The content of both components of the subject are relevant for the examination. The seminar paper will count 50% towards the grade for the module. The paper will not be graded.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Content of the lectures

- "Grundlagen des nachhaltigen Bauens"
- "Verkehrstechnik und Verkehrsplanung Grundmodul"
- "Siedlungswasser- und Abfallwirtschaft Grundmodul"

#### **Content:**

In this module the interrelations between concepts of urban planning, engineering and architecture are shown along with the corresponding energy, material and traffic flows. Above all, the realization of the concepts is dealt with in detail. Individual civil engineering projects as well as infrastructure systems and housing projects are considered in more detail and analyzed. The realization of these projects taking account of location, social and societal aspects and the inclusion of energy-related and political aspects is investigated pragmatically on the basis of case studies. New buildings and renovation projects, plus-energy houses (more energy generated than used), and zero emission housing are addressed. At the same time sustainability criteria are dealt with using

various examples in the phases of planning, construction, operation and deconstruction in order to be able to evaluate actively future buildings, structures, systems and developments.

### **Intended Learning Outcomes:**

Students who have attended the lecture are able to:

- Apply the sustainability criteria on the basis of model projects and understand their influences and the interactions of the parameters concerned
- Understand the principles of sustainable developments in towns and cities, neighborhoods, buildings and other civil engineering works, bearing in mind the spatial, structural, material, cultural and societal aspects
- Understand and evaluate various sub-systems such as infrastructure, existing buildings, new buildings, urban planning requirements, energy supply, traffic, mobility, water, waste, nutrition, education, social structure, resources/cycles at the neighborhood level, micro climate, quality of life, societal structures, usage structures and economic structures
- Understand concepts of active and passive building technology and also intelligent building envelopes and building control systems
- Understand factors like comfort, climate, energy consumption, finiteness of resources, carbon emissions and their interaction with each other
- Understand scenario-based analyses and examples and transfer one's understanding of the factors involved to other objects of investigation with one's own solutions.

### **Teaching and Learning Methods:**

Students participating in the lecture select one topic/object each from the following teaching content at the beginning of the semester, which is to be researched intensively throughout the semester. This may include a tour of the site and a presentation. Students will work in small teams of 2-3. At the end of the semester, the results will be presented in the form of a short presentation. The students take an active part in planning the various components of the excursions, partially working out concepts and strategies on their own.

### **Media:**

Transparencies, script (developed on the basis of the key areas covered by the lecture in a given semester), beamer presentations. Excursions and tours to the objects covered in the case studies with supporting guest lectures and guided tours of the sites.

### **Reading List:**

Recommended literature will be announced at the beginning of the semester by the Institute, literature lists are available from the Institute.

### **Responsible for Module:**

Prof. Werner Lang

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Fallstudien nachhaltiger Quartiers-, Stadt- und Infrastrukturentwicklungen (Seminar, 2 SWS)  
Lang W [L], Hernández Chamorro A, Lang W, Schwering K, Theilig K

Nachhaltige Quartiers-, Stadt- und Infrastrukturentwicklungen (Vorlesung, 2 SWS)

Lang W [L], Hernández Chamorro A, Schwering K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV650002: Advanced Topics in Building Information Modeling | Advanced Topics in Building Information Modeling [BIM.advanced]**

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

25-minute presentation in which a special, selected topic from the area of "Building Information Modeling" or "Virtual design and construction" will be discussed in depth. In a 5-minute round, the students then answer the questions of the lecturers and their fellow students. Based on the basic knowledge of the Building Information Modeling course and independent research work, students should be able to demonstrate a deeper understanding of the subject matter.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

completion of the course "Building Information Modelling"

#### **Content:**

Current research topics in Building Information Modeling and Virtual Design and Construction.  
Joint presentations and discussions of current scientific publications.

#### **Intended Learning Outcomes:**

After completing the module the students will be able to:

- understand and analyse current scientific publications on Building Information Modeling and to carry out independent research work in this area of expertise
- perform scientific research in the area of Building Information Modeling

#### **Teaching and Learning Methods:**

The students choose from a list of suggested topics. They study current publications in the respective domain and present their results in a comprehensive oral presentation. This is followed by a joint round in which the results are discussed and interpreted.

**Media:**

Blackboard, Powerpoint Presentations

**Reading List:**

Eastman et al.: BIM Handbook - A guide to Building Information Modeling

**Responsible for Module:**

Alex Braun, alex.braun@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

BIM.advanced - Ausgewählte Themen des Building Information Modelings (Seminar, 2 SWS)

Forth K, Memis I, Borrmann A, Petzold F, Pfitzner F, Vilgertshofer S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV660011: QV Groundwater Modelling 1 | QV Grundwassermodellierung 1

Version of module description: Gültig ab summerterm 2012

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b>        | <b>Self-study Hours:</b>         | <b>Contact Hours:</b>                |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

#### Intended Learning Outcomes:

#### Teaching and Learning Methods:

#### Media:

#### Reading List:

#### Responsible for Module:

Kai Zoßeder

**Courses (Type of course, Weekly hours per semester), Instructor:**

Grundwasser-Modellierung 1 (Übung, 2 SWS)

Rein A, Zoßeder K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### CH0141: Organic Environmental Chemistry | Organische Umweltchemie

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a written, closed-book test of 60 minutes duration. The exam controls through theoretical questions to what extent students are able to recognize the behaviour of organic chemicals (partitioning, speciation, (bio)chemical reactions) in the environment (water, soil, air, biota) and, based on this understanding, to predict their fate (persistence, distribution, bioaccumulation, transformation).

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Introductory courses in General Chemistry, Organic Chemistry and Physical Chemistry.

#### Content:

- Speciation of substances in aqueous systems.
- Intermolecular interactions (H-Bonds, van der Waals forces).
- Prediction of partitioning based on multiparameter linear free energy relationships.
- Air-water partitioning, organic solvent-water partitioning.
- Sorption and bioaccumulation.
- Environmental transformations I: Hydrolysis, Hammett relationships.
- Environmental transformations II: Oxidation & Reduction.
- Prediction of environmental fate.

#### Intended Learning Outcomes:

After attending the course, the students are able to estimate environmental behaviour from molecular structure. Based on functional groups and physicochemical parameters, they can assess in which environmental compartments chemicals will accumulate; estimate their tendency to undergoing long-range transport; and predict potential transformation pathways.

**Teaching and Learning Methods:**

The theoretical principles for chemical processes in the environment including real and virtual models are presented during the lectures, supported by PowerPoint presentations and blackboard work. Accompanying exercises on model calculations allow the students to get familiar with computational aspects of fate and transport of substances in natural environments.

**Media:**

Slides, Board

**Reading List:**

Schwarzenbach, Imboden, Gschwend, Environmental Organic Chemistry, 2017

**Responsible for Module:**

Elsner, Martin; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Environmental Chemistry (Vorlesung, 2 SWS)

Bakkour R, Elsner M ( Popp C )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA10269: Communication and Personality | Kommunikation und Persönlichkeit

Version of module description: Gültig ab summerterm 2011

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>1                   | <b>Total Hours:</b><br>30  | <b>Self-study Hours:</b><br>15   | <b>Contact Hours:</b><br>15                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Studierende zeigen die Bereitschaft, konkrete eigene fragliche Kommunikationssituationen einzubringen und gegebenenfalls zu inszenieren (Studienleistung). In einer Klausur zeigen die Studierenden, dass sie die verschiedenen Voraussetzungen für gelungene Kommunikation verstehen und bestimmte Kommunikationsmuster unterscheiden können (Prüfungsleistung).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Achtung: Voraussetzung für die Teilnahme an diesem Workshop ist, dass jeder eine konkrete fragliche Kommunikationssituation einbringt und bereit ist, diese in einem Rollenspiel lebendig werden zu lassen!

#### Content:

„Man kann nicht nicht kommunizieren“ (P. Watzlawick) – Kommunikation ist also keine Kompetenz neben anderen, Kommunikation geschieht immer. In ihr kommt unsere Persönlichkeit zum Ausdruck und die unterschiedlichen Weisen, wie wir mit Menschen und auch Dingen in Beziehung stehen. Kommunikation und Beziehungsgestaltung sind zentrale Faktoren für die persönliche Lebensqualität und sie entscheiden wesentlich über den Erfolg und die Zufriedenheit in beruflichen Belangen.

Der Workshop bietet zum einen grundlegende und praxisnahe Einsichten der Kommunikationspsychologie, zum anderen ermöglicht er ein vertieftes Verständnis der eigenen Persönlichkeit in der Dynamik von Beziehungen und in Arbeitsstrukturen.

#### Intended Learning Outcomes:

Nach erfolgreicher Teilnahme an diesem Modul sind die Studierenden in der Lage:

- Kommunikation in ihrer Vielschichtigkeit zu verstehen
- zentrale Aspekte gelingender Beziehung und klärender Kommunikationsgestaltung anzuwenden
- eigene Kommunikationsmuster zu identifizieren
- das Entwicklungspotenzial im eigenen Kommunikationsverhalten zu erfassen und umzusetzen.

**Teaching and Learning Methods:**

Präsentation und Diskussion

Erlebnisaktivierende Inszenierung von Kommunikationssituationen

Supervisorisches Coaching zur Klärung von Fragen aus eigenen Kommunikationssituationen der TeilnehmerInnen

Feedback im Rahmen der Gruppe.

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Standing, Voice and Communication - für Frauen (Ausgestattet mit Ausstrahlung und einer Stimme, die trägt) (Workshop, 1 SWS)

Herrmann A

Kommunikation und Persönlichkeit (Gesprächsführung und Coaching) (Workshop, 1 SWS)  
Seitlinger M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA10412: Technical Writing (Engineer Your Text!) | Technical Writing (Engineer Your Text!)

Version of module description: Gültig ab summerterm 2014

|                                         |                             |                                  |                                             |
|-----------------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>1                   | <b>Total Hours:</b><br>30   | <b>Self-study Hours:</b><br>15   | <b>Contact Hours:</b><br>15                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

For their coursework (=immanent examination), students may choose between writing a short persuasive essay or a proposal (max. 1000 words); alternatively, they may compile a scientific abstract for a (hypothetical) paper (max. 250 words) or their thesis (max. 500 words). It is particularly important that students show sensitivity for different audiences and demonstrate their developed knowledge about argumentational structures in the chosen assignment.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Students require adequate English skills (intermediate to post-intermediate).

#### Content:

Fuel your studies by the alternative energy of this workshop. Maximize your skills to write. Increase your writing efficiency. Use sustainable strategies and quality tools. Learn to write TUM (Technical, Understandable, Manageable) documents.

This course will focus on the fundamentals of text manufacturing: materials, processes, designs, assembly methods, quality management, and performance monitoring.

#### Intended Learning Outcomes:

By the end of the course, you are expected to be able to

- identify the role of psychological factors in writing and reading.
- recognize the needs of different audiences.
- show sensitivity to usability demands.
- analyze technical documents and locate features of best-practice writing.

- organize and manage your own writing.

**Teaching and Learning Methods:**

The workshop uses a constructivist approach to document analysis and text production based on recent academic literacy research. Cooperative learning methods like discussions, small group work, peer review, some direct instruction, and the independent work of the students ensure the diversity of knowledge transfer.

**Media:**

Flipcharts, exercise portfolio, Moodle

**Reading List:**

Gopen, G. D. and Swan, J. A. (1990). The science of scientific writing. American Scientist, 78:57-63. Please access this article in advance at: <http://www.americanscientist.org/issues/feature/the-science-of-scientific-writing>

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Engineer Your Text! (Technical Writing for People Who Want More) (Workshop, 1 SWS)

Balazs A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA10450: When Engineers Become Managers | Wenn aus Ingenieuren Manager werden

Version of module description: Gültig ab summerterm 2014

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>1                   | <b>Total Hours:</b><br>30  | <b>Self-study Hours:</b><br>18   | <b>Contact Hours:</b><br>12                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Im Rahmen einer Fallstudie (3-5 Seiten) oder durch das Vorbereiten einer Präsentation (10-15 Min.) beschreiben die Studierenden, welche komplexen Problemstellungen im Management zu erwarten sind, und stellen hierzu Lösungsvorschläge vor (Prüfungsleistung).

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

In den Ingenieur-Disziplinen gibt es für die meisten Aufgabenstellungen erprobte Theorien, Näherungsverfahren und Simulationsansätze. Im Management ist dies anders. Es gibt keine geschlossene, umfassende Theorie; allenfalls Ansätze für isolierte, begrenzte Themenbereiche. In dem Workshop werden bewährte Methoden und Instrumente für Standardsituationen vorgestellt, zusammen mit neuen, bisher nicht veröffentlichten Ansätzen zur Geschäftsoptimierung (Winning Business Models). Besonderen Raum nehmen die Themen Soft Skills und Veränderung ein. In diesem Zusammenhang wird ein neues Charakterstruktur-Ebenen Modell vorgestellt. Ausgewählte Themen werden in Arbeitsgruppen vertieft, die Ergebnisse werden von den Teilnehmern vorgetragen.

#### Intended Learning Outcomes:

Nach erfolgreicher Teilnahme am Seminar sind die Studierenden in der Lage Antworten auf zwei relevante Fragen zu geben:

- was erwartet mich in der Managementpraxis?
- welche Instrumente kann ich für die Lösung typischer Managementprobleme einsetzen?

**Teaching and Learning Methods:**

Vortrag; offener Dialog; Gruppenarbeit; Präsentation; Erfahrungsberichte von Dozenten und Teilnehmern

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Wenn aus Ingenieuren Manager werden (Workshop, ,5 SWS)

Rüll H, Schrems A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### CLA10813: Economic Thinking: Economics | Volkswirtschaftlich Denken

Version of module description: Gültig ab winterterm 2010/11

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>1                   | <b>Total Hours:</b><br>30  | <b>Self-study Hours:</b><br>15   | <b>Contact Hours:</b><br>15                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In einer Präsentation (10-15 Min.) zeigen die Studierenden ihr Verständnis von grundlegenden ökonomischen Zusammenhängen.

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

Die berufliche und private Lebenswelt ist zu einem erheblichen Teil durch ökonomische Determinanten und Kalküle bestimmt. Besonders deutlich wird die Wahrnehmung und die Kommunikation ökonomischer Fragen in Krisen.

Ein Ziel der Veranstaltung ist das Erkennen grundlegender ökonomischer Zusammenhänge. Ökonomische Begriffe und Zusammenhänge als fachliche Grundlage volkswirtschaftlichen Denkens und Handelns werden im Workshop anhand folgender Themen erworben:

1. Wirtschaftliches Denken und Handeln
2. Marktwirtschaftliche Ordnungen
3. Markt und Preisbildung
4. Wirtschaftssubjekte
5. Übung
6. Wirtschaftskreislauf
7. Konjunktur und Stabilität
8. Finanzsystem
9. Fallstudie

**Intended Learning Outcomes:**

Nach der Veranstaltung sind die Studierenden in der Lage grundlegende ökonomische Begriffe und Zusammenhänge zu verstehen.

**Teaching and Learning Methods:**

Vortrag, Gruppenübung, Präsentation, Diskussion, Fallstudie

**Media:**

**Reading List:**

**Responsible for Module:**

Karin Aschenbrücker

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA11108: Leadership | Führung übernehmen

Version of module description: Gültig ab summerterm 2012

|                                         |                            |                                  |                                      |
|-----------------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>1                   | <b>Total Hours:</b><br>30  | <b>Self-study Hours:</b><br>15   | <b>Contact Hours:</b><br>15          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In einer Präsentation analysieren die Studierenden die grundlegenden Konzepte/Methoden und Aufgaben der Personalführung (Prüfungsleistung).

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

Führung kann gelernt werden - sofern die Bereitschaft für diese Aufgabe besteht. Hierzu gehört Selbstreflexion, die Übernahme von Verantwortung und ein Verständnis über die grundlegenden Konzepte und Methoden der Personalführung.

#### Inhalte

- Management und Führung
- Wirksamkeit nachhaltiger Führung
- Führungs-Kompetenzen
- Leistungs-Pyramide
- Aufgaben einer Führungskraft
- Diversity, Interkulturelle Führung
- Kommunikation und Feedback
- Recruiting und Bewerbungsgespräche
- Situative Führung
- Persönlicher Entwicklungsplan

**Intended Learning Outcomes:**

Nach erfolgreicher Teilnahme an diesem Workshop sind die Studierenden in der Lage die Wirksamkeit nachhaltiger Führung in Bezug auf die Leistungs-Pyramide zu veranschaulichen. Weiterhin identifizieren sie sich mit den erlernten Führungs-Kompetenzen und können je nach Situation den angemessenen Führungsstil demonstrieren und auch im Bereich der interkulturellen Führung angemessen reagieren.

**Teaching and Learning Methods:**

Praxisnahe Übungen zur Führungsübernahme, Diskussion

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Führung übernehmen (Workshop mit praxisnahen Übungen (Fallstudie) (Workshop, 1 SWS)

Turbanski J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA11301: Presentation Training with Video Feedback | Präsentationstraining vor der Kamera

Version of module description: Gültig ab summerterm 2015

|                                         |                            |                                  |                                  |
|-----------------------------------------|----------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>1                   | <b>Total Hours:</b><br>30  | <b>Self-study Hours:</b><br>7    | <b>Contact Hours:</b><br>23      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In einer Präsentation (10-15 Min.) zeigen die Studierenden, dass sie sicher präsentieren können und wissen wie man anhand der Körpersprache überzeugt und wirkungsvoll zu einem Publikum spricht.

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

Im Workshop analysieren und üben Studierende, was eine gute Präsentation ausmacht und wie Körpertechnik, Körperhaltung und Sprache für einen bleibenden Eindruck eingesetzt werden können. Anhand von Videoanalysen erhalten die Studierenden konstruktives Feedback.

Präsentationen können auch in englischer Sprache gehalten werden.

#### Themen

- Körpersprachliche und stimmliche Wirkung
- Umgang mit Lampenfieber
- Einsatz von Medien
- Umgang mit Einwänden aus dem Publikum

#### Intended Learning Outcomes:

Nach der Teilnahme sind die Studierenden in der Lage

- sicher und authentisch vor Publikum (und Kamera) aufzutreten

- körpersprachliche Wirkungselemente souverän einzusetzen
- Präsentationen publikumsorientiert und überzeugend zu gestalten

**Teaching and Learning Methods:**

Input, Präsentieren, Video-Feedback

**Media:**

**Reading List:**

**Responsible for Module:**

Bettina Hafner

**Courses (Type of course, Weekly hours per semester), Instructor:**

Brillant Präsentieren - live & vor der Webcam (Online Medientraining für deinen überzeugenden Auftritt) (Workshop, 1,5 SWS)

Bell I

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA11313: Conflict Management and Conducting Discussions | Konfliktmanagement und Gesprächsführung

Version of module description: Gültig ab summerterm 2015

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>1                   | <b>Total Hours:</b><br>30  | <b>Self-study Hours:</b><br>8    | <b>Contact Hours:</b><br>22                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Studierenden dokumentieren in einem Bericht in Form einer schriftlichen Selbstreflexion (3-5 Seiten) ihr Verständnis des eigenen Konfliktverhaltens in schwierigen Gruppensituationen.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

Wenn Menschen intensiv zusammenarbeiten, ergeben sich immer wieder Situationen, die sie als kontrovers, Stress auslösend und unproduktiv erleben. Durch das Aufeinandertreffen gegensätzlicher Interessen, Verhaltensweisen oder Einstellungen entstehen häufig Auseinandersetzungen, die es den Beteiligten erschweren, die eigentlichen Aufgaben zu erledigen und die angestrebten Ziele und Ergebnisse zu erreichen. Konflikte bergen jedoch auch viele positive Chancen und Veränderungspotenziale.

Der Workshop soll die Teilnehmenden sensibilisieren, Streitsituationen frühzeitig zu erkennen und eine konstruktive Haltung zur Situation einzunehmen. Sie lernen, Distanzfähigkeit zu entwickeln, wo sie selbst in Konflikte verwickelt sind, und ein Gespür für Verhandlungsgeschick entwickeln, wo sie als neutrale Dritte zwischen Kontrahenten vermitteln können. Der Workshop soll schließlich Strategien und (Gesprächs-)Techniken vermitteln, mit denen die Teilnehmenden Konflikte konstruktiv deeskalieren und den nachgelagerten Prozess gezielt steuern und strukturieren können.

**Intended Learning Outcomes:**

Nach der Teilnahme sind die Studierenden in der Lage das persönliche Konfliktverhalten zu verstehen, Konflikte zu erkennen, zu bearbeiten und zu lösen. Die Studierenden kennen die Eskalationsstufen im Konfliktverlauf, wissen, wie sie schwierige Situation ansprechen und zwischen Konfliktparteien moderieren.

**Teaching and Learning Methods:**

Durch theoretischen Input erfahren die Studierenden unterschiedliche Konfliktdefinitionen, die diese im Anschluss praktisch anhand von Rollenspielen und Fallarbeiten in Kleingruppen sowie im Plenum üben können

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Kritische Kommunikationssituationen einfach lösen (Workshop, 1,5 SWS)

Hörtlackner R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### CLA11317: Interdisciplinary Lecture Series Environment: Politics and Society | Ringvorlesung Umwelt: Politik und Gesellschaft

Version of module description: Gültig ab summerterm 2015

|                                         |                             |                                  |                                      |
|-----------------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>1                   | <b>Total Hours:</b><br>30   | <b>Self-study Hours:</b><br>15   | <b>Contact Hours:</b><br>15          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

A successful accomplishment of 9 academic performances is mandatory for the examination! The examination consists of a short PowerPoint presentation at the end of the semester. The presentation can be created alone or in groups of two. Everyone has to speak one minute. The examination is ungraded.

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

The lecture series Umwelt (environment) is an interdisciplinary, public lecture organised by the Environmental Department of the Studentische Vertretung (Student Representatives) of the TU Munich. Experts speak e.g. on technical environmental protection, health, consumer and climate protection. In the summer semester, it offers students the opportunity to learn about the political and social dimensions of current ecological topics and research results at a scientific level.

The lecture series Umwelt (environment) is offered in the winter semester in the module CLA11200 Ringvorlesung Umwelt: Ökologie und Technik (Lecture series on the environment: ecology and technology). It is only possible to gain given credits twice for the lecture series within each study program.

#### Intended Learning Outcomes:

Students are able to follow expert presentations on political and social dimensions of environmental problems and identify core theses and central facts.

**Teaching and Learning Methods:**

Lectures, presentations, discussions

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Will Technology Save Us All? A Glimpse into a Sustainable Future (Ringvorlesung Umwelt)  
(Vorlesung mit integrierten Übungen, 1,5 SWS)

Biller B, Dörringer L, Kopp-Gebauer B, Recknagel F, Slanitz A

Responsibility in Times of (Climate) Change (Ringvorlesung Umwelt) (Vorlesung mit integrierten Übungen, 1,5 SWS)

Dörringer L, Kopp-Gebauer B, Recknagel F, Slanitz A, Trentmann L

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA20201: Complex Systems | Komplexe Systeme

Version of module description: Gültig ab summerterm 2012

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>2                   | <b>Total Hours:</b><br>60  | <b>Self-study Hours:</b><br>30   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Studierenden zeigen in einer Präsentation zu Modellierungskonzepten oder fachspezifischen Anwendungen, dass sie die Grundbegriffe der Theorie komplexer Systeme verstehen und bei der Vermittlung fächerübergreifender Methoden adäquat anwenden können.

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

Die Themen Komplexität und Komplexe Systeme sind ein hochaktuelles Forschungsgebiet in Natur-, Ingenieur-, Wirtschafts- und Sozialwissenschaften. Komplexe dynamische Systeme (z.B. Materialien, Strömungen, Wetter, Organismen, Populationen, Märkte, Gesellschaften) bestehen aus vielen Elementen (z.B. Moleküle, Zellen, Menschen), aus deren Wechselwirkungen neue Ordnungen und Strukturen, aber auch Instabilität und Chaos entstehen.

Können wir aus Chaostheorien, aus der Entstehung von Ordnung und Selbstorganisation in der Natur lernen, unsere technischen und sozialen Systeme zu steuern? Wo sind grundlegende Unterschiede in der Dynamik von Natur und Gesellschaft? Welche Konsequenzen ergeben sich für unser Handeln?

1. Grundbegriffe der Systemtheorie
2. Modellierung dynamischer Systeme in Natur-, Technik- und Sozialwissenschaften (Themenfelder: Evolution, Geist und Gehirn, Wirtschaft und Gesellschaft)
3. Philosophische Implikationen in Wissenschaftstheorie und Ethik

**Intended Learning Outcomes:**

Die Teilnehmer sind in der Lage Grundlagen der fachübergreifenden Systemforschung zu reproduzieren und anhand exemplarischer Themenfelder der Modellierung dynamischer Systeme in Natur-, Technik- und Sozialwissenschaften darzustellen. Insbesondere können sie ihre Erfahrungen in der interdisziplinären Vermittlung und Transformation fachspezifischen Wissens ausführen.

**Teaching and Learning Methods:**

Vorlesung, Referate, Selbststudium

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Komplexe Systeme (Emergenz und Selbstorganisation in Natur, Technik und Gesellschaft)  
(Seminar, 2 SWS)

Thürmel G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA20424: Intercultural Encounters | Interkulturelle Begegnungen

Version of module description: Gültig ab winterterm 2002/03

|                                         |                                    |                                  |                                             |
|-----------------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>2                   | <b>Total Hours:</b><br>60          | <b>Self-study Hours:</b><br>38   | <b>Contact Hours:</b><br>22                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In einer Präsentation werden eigene und fremde kulturelle Standards reflektiert und diskursiv mit den anderen Teilnehmern ausgetauscht (Studienleistung). Zudem verfassen die Studierenden ein Lerntagebuch von etwa 5 Seiten, in dem sie die Gefahren von Stereotypisierung und das verbindende Potential interkultureller Begegnungen begründet wiedergeben (Prüfungsteilleistung).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gute Deutschkenntnisse (Niveau B2)

#### Content:

Internationale Studierende können sich umso leichter in Hochschule, Gesellschaft und Arbeitswelt integrieren, je mehr Kontakt sie zu ihren deutschen Mitstudierenden haben. Wollen deutsche Studierende im Gegenzug auf dem internationalen Arbeitsmarkt bestehen, so ist der Erwerb interkultureller Kompetenzen unerlässlich.

Die Veranstaltung gibt internationalen und deutschen Studierenden die Möglichkeit, sich ein Semester lang besser kennen zu lernen: Auftakt und Abschluss bilden je ein eintägiger Workshop. Unter Anleitung eines internationalen Trainer/-innenteams werden die Teilnehmenden für andere Kulturen sensibilisiert und reflektieren die eigenen Wertvorstellungen sowie den Umgang mit deutschen und internationalen Mitstudierenden. Im weiteren Verlauf treffen sich die Studierenden bei kulturellen, sportlichen und fachlichen Events wieder und können so ihre Kontakte vertiefen.

#### Intended Learning Outcomes:

Nach der Teilnahme sind die Studierenden in der Lage

- eigene und fremde kulturelle Standards zu reflektieren
- die Gefahren von Stereotypisierung im interkulturellen Kontext zu erkennen

- kompetenter mit kulturellen Unterschieden und möglichen Konfliktsituationen umzugehen

Die Studierenden können Softskills im interkulturellen Bereich umsetzen und bei gemeinsamen Veranstaltungen mit deutschen und internationalen Studierenden praxisnah und anschaulich weiterentwickeln.

**Teaching and Learning Methods:**

Wir verwenden eine methodische Vielfalt aus interaktiven Aufgaben (z.B. Arbeit an Fallbeispielen, Simulationen, Gruppenarbeit) und Kurzvorträgen.

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Intercultural Encounters (Come to Munich - Be at Home!) (Workshop, 1,5 SWS)

Prahl M, Skowron E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA20710: Global Diversity Training | Global Diversity Training

Version of module description: Gültig ab winterterm 2013/14

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>2          | <b>Total Hours:</b><br>60   | <b>Self-study Hours:</b><br>38   | <b>Contact Hours:</b><br>22                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Students will deal with their own cultural background in a short group presentation and deeply reflect on the learning outcomes of the workshop in a learning summary (100% of grade).

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

Collaboration in international teams is becoming a crucial everyday part of working environments. It brings numerous benefits, but can also lead to misunderstandings, confusions and conflicts that can hinder productivity.

The aim of the training is to prepare participants for teamwork from an intercultural perspective and especially to reflect the influence of diversity on the team process in international teams. To achieve this goal, we will work with science-based models, short lectures and numerous exercises with a strong focus on the relevance for your professional and daily life.

#### Intended Learning Outcomes:

After this workshop you will be able to individually deal with our own cultural background and its impact on intercultural collaboration

- Analyze the role and tasks of team leaders in an intercultural context.
- Develop strategies for case studies in international teams.
- be able to analyze situations of your professional life in an international team.

**Teaching and Learning Methods:**

The workshop will be a mix of input, case studies, discussions and group work.

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Global Diversity (Successful in International Teams) (Workshop, 1,5 SWS)

Prahl M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### CLA20910: Gender Competence as Core Qualification | Genderkompetenz als Schlüsselqualifikation

Version of module description: Gültig ab winterterm 2010/11

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>2                   | <b>Total Hours:</b><br>60  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>15                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In einer schriftlichen Ausarbeitung von 5 Seiten zeigen die Studierenden anhand von aktuellen Fragestellungen, zu Themen wie Frauenquote, Vereinbarkeit und Rollenveränderung von Eltern, wie (veränderbare) Geschlechterrollen unsere Wirklichkeit prägen und wie sich durch einen konstruktiven und reflektierten Umgang damit auch persönliche Möglichkeiten erweitern lassen (Prüfungsleistung).

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

An der Hochschule sind die Anforderungen und Ansprüche in den letzten Jahren stark gestiegen. Einhergehend mit den Veränderungen der Hochschule haben sich auch die Rollenanforderungen an ihre Mitglieder gewandelt. Auch Männer- und Frauenbilder sind in einem stetigen Veränderungsprozess. Geschlechterrollen beeinflussen unser alltägliches Verhalten und unsere Wahrnehmung. Hier setzt der Workshop an:

Welche Geschlechterrollen und Vorbilder prägen heute unsere Wirklichkeit? Welchen Einfluss haben andere Kulturen auf unser Verhalten? Und wie können wir mit den bestehenden Geschlechterrollen konstruktiv umgehen und unsere persönlichen Möglichkeiten erweitern? Wo treffe ich in meinem Umfeld auf genderspezifische Handlungs-Muster und -Strukturen?

#### Intended Learning Outcomes:

Nach der erfolgreichen Teilnahme an diesem Workshop sind die Studierenden in der Lage darzustellen, welche Geschlechterrollen und Vorbilder unsere Wirklichkeit prägen. Weiterhin

können die Studierenden veranschaulichen wie sie mit den bestehenden Geschlechterrollen - nicht nur - in ihrem Umfeld konstruktiv umgehen.

**Teaching and Learning Methods:**

Das Seminar beinhaltet theoretische Inputs, Gruppenarbeit, Rollenspiele und kollegiales Feedback.

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Genderkompetenz als Schlüsselqualifikation (Online-Workshop und interaktives Lernprojekt)  
(Workshop, 1 SWS)

Fänderl W, Quindeau A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA21008: Fundamental Principles of Globalisation | Grundlagen der Globalisierungsforschung

Version of module description: Gültig ab winterterm 2010/11

|                                         |                            |                                  |                                      |
|-----------------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>2                   | <b>Total Hours:</b><br>60  | <b>Self-study Hours:</b><br>38   | <b>Contact Hours:</b><br>22          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Studierenden reflektieren in einem Essay (3-6 Seiten) an einem Beispiel globale Auswirkungen privaten oder beruflichen Handelns und diskutieren Lösungsansätze.

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

Anhand bestimmter Rohstoffe (z.B. Aluminium) und Produkte (z.B. Computer) werden beispielhaft globale Zusammenhänge aufgezeigt, die im alltäglichen Gebrauch dieser Stoffe üblicherweise ausgeblendet werden. Diese finden sich auf menschenrechtlich-individueller Ebene genauso wieder wie auf der politischen, sie sind auf einen nachhaltigen Umgang mit der Umwelt genauso bezogen wie auf die Wirtschaft. Die Ursachen dafür sind teilweise struktureller Natur, die Konsequenzen aus der teilweise ungerechten Vernetzung sind genauso global wie auch deren Ursachen.

Anhand von den zukünftigen Arbeitsfeldern der TeilnehmerInnen werden theoretische Modelle praktisch aufgezeigt.

#### Intended Learning Outcomes:

Nach der Teilnahme an der Veranstaltung sind die Studierenden in der Lage, selbstständig über die Auswirkungen ihrer privaten und beruflichen Handlungen in Bezug auf globale Verbindungen zu recherchieren und zu reflektieren. Sie können globale Güterketten von Produkten und Rohstoffen analysieren und auf ihre Auswirkungen hin hinterfragen. Am Ende des Kurses können die TeilnehmerInnen das Modell des ungleichen Tausches anwenden und verstehen die sich

daraus ergebende Ungleichverteilung von Wohlstand in der Welt. Die Studierenden kennen verschiedene Lösungsansätze für eine global gerechtere Welt und können sie auf ihre Vor-, Nachteile und Realisierbarkeit untersuchen.

**Teaching and Learning Methods:**

Die Teilnehmer/innen werden an praktischen, teils eigenen Beispielen und mit partizipativen Methoden konkrete Produkte untersuchen und diese in theoretische Hintergründe einbetten. Die Methodik basiert auf dem didaktischen Konzept des Globalen Lernens.

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Globale Zusammenhänge erkennen (Grundlagen der Globalisierungsforschung für TechnikerInnen) (Workshop, 1,5 SWS)

Haberl M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA21213: Individual Change Management | Individual Change Management

Version of module description: Gültig ab winterterm 2010/11

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>2                   | <b>Total Hours:</b><br>60  | <b>Self-study Hours:</b><br>38   | <b>Contact Hours:</b><br>22                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Studierenden bearbeiten eine schriftliche Fallstudie, in der sie ihr Verständnis der verschiedenen Aspekte des Individual Change Management wiedergeben (Prüfungsleistung).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Die Studierenden sind bereit sich mit persönlichen Veränderungsprozessen und dem eigenen Rollenverständnis auseinanderzusetzen.

#### Content:

Individual Change Management (ICM) betrifft alle Herausforderungen zu der Frage, wie man Veränderungen – welcher Art auch immer – im eigenen Lebens- und Karriereplan integrieren und bei Bedarf gut meistern kann. ICM plant dabei die Veränderungsprozesse, führt den Wandel durch und stabilisiert und kontrolliert die Veränderungen.

Leben und Karriere will einerseits zwar geplant werden, Veränderungen im Privat- oder Erwerbsleben müssen andererseits aber auch bedacht sein. Damit eigene Lebens- und Karriereentwürfe umgesetzt werden können, müssen (Lebens)Ziele stets überprüft, gegebenenfalls korrigiert oder neu gesucht werden. Hier setzt der Workshop an.

#### Intended Learning Outcomes:

Nach der Teilnahme sind die Studierenden in der Lage

- zwischen Chancen und Gefahren bei (persönlichen) Veränderungsprozessen zu differenzieren
- das eigene Rollenverständnis zu reflektieren

- durch die Definition persönlicher Meilensteinen und die Wahrnehmung und Mobilisierung von (inneren) Ressourcen Veränderungen strukturiert anzugehen und umzusetzen.

**Teaching and Learning Methods:**

Jede Themeneinheit bewegt sich zwischen Selbsterfahrung, Information und Reflexion:  
Biographiearbeit; Interaktions-, Entspannungs-, Imaginationsübungen; Kreativarbeit; Coping bzw. Resilienzförderung (NLP) und Ressourcenaktivierung; Kollegiale Beratung (ZRM).

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Individual Change Management (Persönliche Veränderungsprozesse initiieren und erfolgreich gestalten) (Workshop, 1 SWS)

Kölbl C ( Recknagel F )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA21601: Ethics and Responsibility II | Ethik und Verantwortung II

Version of module description: Gültig ab summerterm 2016

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>2                   | <b>Total Hours:</b><br>60  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>15                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Das Modul wird mit einem Referat abgeschlossen (30min), in dem die Studierenden zentrale Argumente zu einem ethischen Problem erörtern und in der Diskussion eine eigene Position vertreten.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Fortgeschrittene Studierende.

Erfolgreiche Teilnahme an einer einführenden Ethikveranstaltung.

#### Content:

Vertiefende Behandlung von Themen aus den Bereichen Umweltethik, Wissenschaftsethik, Technikethik, Medizinethik oder Informations-/Medienethik in philosophischer Perspektive unter Berücksichtigung aktueller Forschungsfelder.

#### Intended Learning Outcomes:

Nach der Teilnahme sind die Studierenden in der Lage die wichtigsten Argumente eines Bereichs der Angewandten Ethik zu verstehen und in andere Kontexte zu übertragen. Sie kennen den aktuellen Stand der Diskussion und können eine eigene Position in Diskussionen vertreten.

#### Teaching and Learning Methods:

Textanalyse, Webplattform, Diskussion, Präsentation

#### Media:

**Reading List:**

Wird im Rahmen der Veranstaltung zur Verfügung gestellt

**Responsible for Module:**

Dr. Eva Sandmann

**Courses (Type of course, Weekly hours per semester), Instructor:**

Ethics of Responsibility: Current Areas of Application (Seminar, 2 SWS)

Stadler K, Wernecke J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### CLA30267: Communication and Presentation | Kommunikation und Präsentation

Version of module description: Gültig ab summerterm 2014

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In gezielten Präsentationssequenzen zeigen die Studierenden Ihre Souveränität und Überzeugungskraft und erhalten dabei von der Gruppe Feedback (Prüfungsteilleistung 50%). Sie analysieren verschiedene Theorien über förderliche und hinderliche Kommunikations- bzw. Präsentationsweisen in einem kurzen Essay (1000 - 1500 Worte) (Prüfungsteilleistung 50%).

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

Kommunikation meint in der Regel die dialogische Kommunikation. Gemeinsam werden förderliche und hinderliche Verhaltens- und Kommunikationsweisen anhand der folgenden Inhalte erarbeitet:

- Grundlagen der Kommunikation
- Konstruktives Feedback
- Effektive und zielgerichtete Gesprächsführung

Mit ausgewählten Übungen haben die Studierenden Gelegenheit Ihre Kommunikationskompetenz zu erproben und zu entwickeln.

#### Intended Learning Outcomes:

Nach der Teilnahme sind die Studierenden in der Lage kompetenter zu kommunizieren und wirkungsvoller zu präsentieren. Sie kennen zudem die Inhalte für überzeugende Präsentationsfähigkeit:

- Aspekte der verbalen und nonverbalen Kommunikation

- Aufbau einer Präsentation
- Visualisierung der Inhalte
- Aktivierung der Zuhörer

**Teaching and Learning Methods:**

Ausarbeitung der Präsentationsinhalte (Kurzpräsentation), Präsentationstraining mit Medieneinsatz im Plenum, Einzelarbeit, Gruppenarbeit, Trainerinput, Feedback (mündlich und schriftlich), zusätzliche schriftliche Ausarbeitung (Essay) möglich aber nicht erforderlich.

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Kommunikation und Präsentation (Workshop, 2 SWS)

Mende W, Recknagel F, Zeus R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA30621: Environmental Chemicals and Environmental Justice | Umweltchemikalien und ökologische Gerechtigkeit

Version of module description: Gültig ab winterterm 2010/11

|                                         |                            |                                  |                                      |
|-----------------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>68   | <b>Contact Hours:</b><br>22          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Studierenden zeigen in einem Vortrag, welche moralischen Problemstellungen sich aus der Verwendung von Umweltchemikalien erschließen lassen (Prüfungsteilleistung 50%) und begründen ihren eigenen Standpunkt in einem Essay (Prüfungsteilleistung 50%). Die Gesamtnote berechnet sich aus diesen zwei Elementen.

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

Auch bei bestimmungsgemäßem Gebrauch von chemischen Stoffen können Schäden an Umwelt und Lebewesen nie ganz ausgeschlossen werden. Um die damit verbundenen Risiken abzuschätzen, wurden Grenzwerte festgelegt. Sie beruhen auf human- und ökotoxikologischen Untersuchungen und analytischen Konzentrationsbestimmungen der fraglichen Stoffe und deren Metabolite. Diese Untersuchungen sind sehr aufwändig und langwierig. Demgegenüber hat Martin Scheringer eine alternative Methode entwickelt, die einfacher ist und eine bessere Prognosequalität besitzt, so dass eine Gefährdungsbeurteilung möglich ist, bevor Schäden eintreten können. Eine mögliche Folge ist zwar, dass später als ungefährlich einzustufende Stoffe nicht frühzeitig in die Anwendung kommen, dafür wird aber ausgeschlossen, dass Unbeteiligte, die keinen Nutzen an dem Einsatz dieser Stoffe haben, Schäden oder Einbußen Ihrer Lebensqualität hinnehmen müssen.

**Intended Learning Outcomes:**

"Nach der Teilnahme sind die Studenten in der Lage die Grundkonzeption und die -probleme der Umweltchemie zu verstehen und erklären. Sie können das neue Konzept der Chemikalienbewertung von Scheringer darstellen. Zudem kennen sie die Grundlagen des europäischen Chemikalienrechts REACH. Die Studierenden entwickeln einen ersten Einblick in die Philosophie der Chemie."

**Teaching and Learning Methods:**

Einführungsreferate der Dozenten, Studium einschlägiger Texte durch Studierende, Präsentationen von Studierenden, Diskussion.

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Umweltchemikalien und ökologische Gerechtigkeit (Seminar, 1,5 SWS)

Lerf A, Wernecke J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA30704: Thinking, Perceiving, and Knowing | Denken, Erkennen und Wissen

Version of module description: Gültig ab summerterm 2012

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>67   | <b>Contact Hours:</b><br>23                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Das Modul wird mit einer Modulprüfung in Form eines Essays (1000-1500 Wörter, inkl. unbenotetem Referat zur Vorbereitung) abgeschlossen. 'Dadurch dokumentieren die Studierenden, dass sie zentrale Grundprobleme der Erkenntnistheorie verstanden haben und veranschaulichen können. Im Essay (Prüfungsleistung) erörtern die Studierenden eine zentrale erkenntnistheoretische Fragestellung und dokumentieren damit ein vertieftes Verständnis der Problemstellung.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

In unserem alltäglichen Sprachgebrauch verwenden wir die Ausdrücke »Denken«, »Erkennen« und »Wissen« oft sehr ungenau, zuweilen sogar synonym. Hingegen hat bereits die antike Philosophie wichtige Abgrenzungen formuliert, die in der Neuzeit und Moderne spezifische Weiterentwicklungen bis hin zur aktuellen Neuro-Philosophie erfahren haben.

Das Seminar vermittelt eine Übersicht der europäischen Klassiker der Erkenntnistheorie, indem es die unterschiedlichen Ansätze zentraler Autoren pointiert vor- und zur Diskussion stellt. Die vorgestellten Ansätze reichen von der Ontologie und Metaphysik, dem Rationalismus, Idealismus und Empirismus bis zu den aktuellen empirischen Kognitionswissenschaften. Vor diesem Hintergrund soll auch der Frage nachgegangen werden, welches Verständnis von Wissenschaft hieraus womöglich resultiert (et vice versa).

**Intended Learning Outcomes:**

Die Teilnehmer besitzen vertiefte Grundkenntnisse über exemplarische Problemfelder der Erkenntnistheorie und verstehen Grundprobleme des Erkennens. Sie sind in der Lage eine zentrale erkenntnistheoretische Fragestellung in schriftlicher Form zu erörtern und deren Relevanz für moderne Erkenntnis- und Wissenschaftskonzepte sowie für die Gesellschaft argumentativ einzuordnen.

**Teaching and Learning Methods:**

Essay, Vorlesung, textbasiertes Seminar, Referate, Gruppenarbeit, Diskussionen, Selbststudium insbes. Lektüre / Erarbeitung von Texten

**Media:**

Skripte / Reader, Thesenpapiere, Tafelbilder, Power-Point

**Reading List:**

**Responsible for Module:**

PD Dr. Jörg Wernecke

**Courses (Type of course, Weekly hours per semester), Instructor:**

Denken, Erkennen und Wissen (Eine Einführung in die Erkenntnistheorie) (Seminar, 1,5 SWS)  
Wernecke J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### CLA31900: Lecture Series Environment - TUM | Vortragsreihe Umwelt - TUM

Version of module description: Gültig ab winterterm 2019/20

|                                         |                             |                                  |                                             |
|-----------------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>67   | <b>Contact Hours:</b><br>23                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a poster created in a group of 2-3 people connecting topics from at least two lectures. In order to collect material for the poster, participants have to organize themselves in discussion groups with 5-6 people.

Each discussion group will split into two groups for the poster. At the end of the semester the poster has to be presented. Every member of the poster group has to speak one minute. The grade will consist of the poster and its presentation.

Mandatory requirements for the examination

For the 3-ECTS course a successful accomplishment of 16 academic performances is mandatory for the examination!

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

The systematic integration of education for sustainable development at the university is an extremely complex challenge that can only be addressed through a plural and multi-perspective approach. Within the framework of the UNESCO World Programme of Action "Bildung für Nachhaltige Entwicklung" (BNE; =Education for Sustainable Development), the interdisciplinary lecture series Umwelt - TUM takes place at the TUM Campus Garching, which deals with changing topics in the field of environmental sustainability.

It is organized by the newly founded branch of the environmental department AStA TUM at the Garching campus to promote sustainability awareness at TUM and to offer interested students the opportunity to deal with the topic in more detail.

**Intended Learning Outcomes:**

After successful participation in this module, students are able to understand lectures at a high scientific level and reproduce central statements. Students are able to comprehend analyses of sustainable development and are familiar with formulating their own positions and justifying them in discussions. Furthermore, they know where they can explore the topic of sustainability in more detail on campus, whether in the form of course offerings, internships, projects or thesis.

**Teaching and Learning Methods:**

It consists of six lectures and an organizational meeting at the beginning. Each lecture includes two 40-minute presentations, a 15-minute break and a subsequent 45-minute discussion with the speakers, which is realized in cooperation with the Zentrum für Schlüsselkompetenzen (Center for Key Competencies) of the Faculty of Mechanical Engineering.

The lectures and presentation slides will be uploaded to the online learning platform Moodle.

As homework, students will prepare a short report of the lectures and the discussion session. In addition, introductory and further literature will be addressed to enhance more detailed discussions of the lectures.

**Media:**

**Reading List:**

**Responsible for Module:**

Dr. phil. Alfred Slanitz (WTG@MCTS)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Will Technology Save Us All? A Glimpse into a Sustainable Future (Ringvorlesung Umwelt)  
(Vorlesung mit integrierten Übungen, 1,5 SWS)

Biller B, Dörringer L, Kopp-Gebauer B, Recknagel F, Slanitz A

Responsibility in Times of (Climate) Change (Ringvorlesung Umwelt) (Vorlesung mit integrierten Übungen, 1,5 SWS)

Dörringer L, Kopp-Gebauer B, Recknagel F, Slanitz A, Trentmann L

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### CLA90142: Self-Competence - Intensive Course | Selbstkompetenz - intensiv

Version of module description: Gültig ab winterterm 2013/14

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>1                   | <b>Total Hours:</b><br>30  | <b>Self-study Hours:</b><br>12   | <b>Contact Hours:</b><br>18                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung besteht aus einem Bericht in Form einer Selbstreflexion (3 Seiten), die 4 Wochen nach Ablauf des Kurses erstellt wird und die persönliche Entwicklung (Veränderung im Lern- und Arbeitsverhalten) nachzeichnet.

#### Repeat Examination:

Next semester / End of Semester

#### (Recommended) Prerequisites:

Die Studierenden sollten in den Kurs ein persönliches Anliegen mitbringen, d.h. den Wunsch, ein bestimmtes Verhalten zu verändern, um mehr Erfolg im Studium und in Prüfungen zu erzielen.

#### Content:

Das Modul dient grundsätzlich der Verbesserung der eigenen Lern- und Arbeitsfähigkeit. Folgende Themen werden innerhalb des Moduls vermittelt:

- Ziele entwickeln und erreichen
- Aktivierung eigener Ressourcen
- Umgang mit Stress und Emotionen
- Aspekte von Hochbegabung und Hochsensibilität
- Umgang mit Ängsten und Blockaden
- Zukunfts-Visionen aufbauen und Motivation stärken
- Mit der eigenen Energie haushalten

#### Intended Learning Outcomes:

Nach der Teilnahme an einem Kurs aus diesem Modul sind die Studierenden in der Lage, ihr eigenes Lern- und Arbeitsverhalten zu analysieren, zu verstehen, welches Verhalten zu

Misserfolgen führt und eigene Lösungsansätze für ein erfolgreicherer Arbeiten zu entwickeln, das Leistung und Gesundheit gleichermaßen im Blick behält.

**Teaching and Learning Methods:**

Gruppenarbeit, Selbstreflexion, Theorie-Inputs

**Media:**

Präsentationen, Hörbeispiele, Übungsblätter, Seminartagebuch etc.

**Reading List:**

**Responsible for Module:**

Bettina Hafner (bettina.hafner@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Wegweiser durch schwierige Zeiten (Wie Sie nach Rückschlägen wieder kraftvoll durchstarten)

(Workshop, 1,5 SWS)

Cavalieri I ( Recknagel F )

Erfolgreich durchs Studium. Selbstmanagement in herausfordernden Zeiten (Online-Kurs)

(Workshop, 1,5 SWS)

Hafner B ( Recknagel F ), Kronenberger U, Müller-Hotop R, Reichhart T

Erste Hilfe für Nervosität und Prüfungsängste (Workshop, 1,5 SWS)

Hafner B, Kronenberger U ( Recknagel F )

Selbstkompetenzen trainieren (Wie Sie sich selbst erfolgreich durchs Studium managen)

(Workshop, 1,5 SWS)

Hafner B, Messutat J

Zeit- und Selbstmanagement (Workshop, 1,5 SWS)

Hann S

Ressourcentraining (Eigene Stärken erkennen und wirkungsvoll einsetzen) (Workshop, 1,5 SWS)

Houben M

Schluss mit dem Aufschieben (Workshop, 1,5 SWS)

Kronenberger U

Selbstführung: Ja klar! Aber wie? (Workshop, 1,5 SWS)

Mehrl F

Digital Reset (Besser studieren mit life media balance) (Workshop, 1,5 SWS)

Miller M

Rewrite Your Life (Workshop, 1,5 SWS)

Milovic T

Selbstwahrnehmung, Improvisation und Körpersprache (Raus aus dem Kopf, rein in den Körper)  
(Workshop, 1,5 SWS)

Molin V

Keine Angst vor der Angst (Bewusster Umgang mit Lampenfieber und Präsentationen) (Workshop,  
1,5 SWS)

Mornell A

Mein innerer Kompass – Wie Werte meine Ziele und Träume stärken (Workshop, 1,5 SWS)

Schnack Q

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### EI04004: Strategic Management for Engineers | Strategic Management for Engineers

Version of module description: Gültig ab summerterm 2017

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination is done in written form (60 min) at the end of the semester. Considering the learning objectives the theoretical and practical concepts of strategic management will be covered. The students should be able to explain notions, concepts, methods and the background of the covered topics. The students should also be able to discuss different solutions of specific practical problems from the entrepreneurial practise.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

No requirements

#### Content:

Strategic environment  
 Development of the macro environment  
 Analysis of competitors and markets  
 Analysis of own capabilities  
 Ressources, competencies and distinct capabilities  
 Value chain and value system  
 Strategic purpose (vision, mission, values; stakeholders)  
 Business strategy  
 Identifying strategic business units  
 Competitive strategies (cost leadership, differentiation, focus)  
 Corporate strategy and diversification  
 Forward and backward integration  
 Value creation and the corporate parent

Portfolio Management  
Innovation and entrepreneurship  
Technology push or market pull  
Product or process innovation  
Open or closed innovation  
Technological or business model innovation  
Mergers, acquisitions and alliances  
Strategy planning process  
Organisation of companies  
Change Management  
Excursion to the corporate strategy department of a high tech company

**Intended Learning Outcomes:**

After successful completion of the module students have an overview on how strategic planning and decision-making processes are carried out in companies. They know the prerequisites (in addition to a suitable product or a suitable business idea) that are necessary in order to successfully position a business in the market. In addition, they are able to evaluate products or business ideas, taking into account the market environment and the competitive situation. They are closer to being able to prepare sound management decisions.

**Teaching and Learning Methods:**

The lecture is accompanied by intense discussions about pros and cons of specific strategy tools. There will be also discussions about case studies of specific companies.

**Media:**

Power Point Slides, Animations, Blackboard

**Reading List:**

Recommended literature:  
Gerry Johnson: Exploring Strategy - Text and Cases

**Responsible for Module:**

Sigl, Georg; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Strategic Management for Engineers (Vorlesung, 2 SWS)

Hepp A [L], Sauerbrey J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### EI0699: Urban Energy Systems and modern infrastructure for cities | Stadtenergiesysteme und moderne städtische Infrastruktur [UESMIC]

Version of module description: Gültig ab summerterm 2019

|                                  |                            |                                  |                                      |
|----------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5            | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung besteht aus einer 60 minütigen Klausur, in der die Studierenden sowohl kurze Text- und Multiple-Choice-Fragen zur Prüfung der Methodenkompetenz, als auch einfache Rechenaufgaben zur Überprüfung der Beherrschung der vorgestellten Anwendungen und insbesondere den Berechnungen zur Auslegung von Komponenten der Infrastruktur bearbeiten. Weitere Textaufgaben dienen dazu die Fähigkeit die Größenordnung abzuschätzen auch wenn nur unvollkommene Informationen vorliegen zu prüfen. Die Klausur wird benotet und es sind keine Hilfsmittel zugelassen.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

none

#### Content:

A short introduction to urban planning is given as an overarching framework. As the data base for further analysis, statistics about the population and employment as well as building data banks of example cities are used. The focus lies on an examination of the different energy demands such as room and process heating and cooling, electrical energy and fuels. These results are then applied to a multi-modal grid planning for remote heating and cooling and the electrical grid. In addition, a short introduction into water supply and food logistics as well as garbage and waste water disposal with a special emphasis on a possible energetic use of the latter is given. Furthermore, urban traffic is examined. An integrated and holistic view in all the named areas is always the guiding idea.

### **Intended Learning Outcomes:**

After finishing this module the students understand the complexity of the technical system "city". They are able to repeat the build-up of building data banks as well as basics of geo information systems (GIS). Additionally, they can evaluate and perform order of magnitude estimates in this area. They understand the basics of the urban supply and disposal infrastructure, especially in the field of energy, as well as the urban climate and are able to analyze and, in simplified cases, calculate the relevant loss mechanisms. The students recognize the advantages of the multi-modal analysis as an important method for future urban planning.

### **Teaching and Learning Methods:**

In the course of this module lectures and tutorials are given. The lectures are presentations which allow the covering of the width of topics discussed. For the tutorials the students get exercise sheets one week in advance to work on and the results are discussed at the blackboard in the tutorials. This helps to repeat and deepen the knowledge of the chosen topics.

### **Media:**

There is a MOOC that was prepared based on the module lecture. In addition, several theses will be relevant. Details will be given at the beginning of the lectures.

### **Reading List:**

Bott, Helmut; Grassl, Gregor C.; Anders, Stephan (Hg.) (2018): Nachhaltige Stadtplanung. Lebendige Quartiere - Smart cities - Resilienz. Institut für Internationale Architektur-Dokumentation. Zweite Auflage (überarbeitet und aktualisiert). München: Edition DETAIL (Edition DETAIL).

Keirstead, James; Jennings, Mark; Sivakumar, Aruna (2012): A review of urban energy system models: Approaches, challenges and opportunities. In: Renewable and Sustainable Energy Reviews 16 (6), S. 3847–3866. DOI: 10.1016/j.rser.2012.02.047.

World Urbanization Prospects - Population Division - United Nations. Online <https://population.un.org/wup/Publications/>

Bundesministerium für Ernährung und Landwirtschaft (BMEL) (Hg.) (2019): Deutschland, wie es isst. Der BMEL-Ernährungsreport 2019. Berlin.

### **Responsible for Module:**

Hamacher, Thomas; Prof. Dr.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Stadtenergiesysteme und moderne städtische Infrastruktur (Vorlesung mit integrierten Übungen, 4 SWS)

Hamacher T, Odersky L, Molar Cruz A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### EI1289: Electrical Engineering | Elektrotechnik

Version of module description: Gültig ab summerterm 2019

|                                  |                            |                                  |                                      |
|----------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5            | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>105  | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Prüfungsleistung wird in Form einer Klausur (90 min) erbracht. In dieser soll nachgewiesen werden, dass in begrenzter Zeit mit Hilfsmittel (2 handgeschriebene A4-Seiten) in den Veranstaltungen des Moduls behandelte Grundaufgaben gelöst werden können. Die Klausur besteht aus Fragen, in dem das Verständnis geprüft wird, und Aufgaben, in den z.B. eine Kurzschlussberechnung eines Transformators berechnet werden müssen. Mit den Prüfungsaufgaben wird das Erreichen der angestrebten Lernergebnisse des Moduls geprüft. Die Prüfungsfragen gehen über den gesamten Vorlesungsstoff.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Grundkenntnisse der elektrischen Energietechnik;

#### Content:

Elektrische Größen und Grundgesetze  
 Elektromagnetismus  
 Analogien des elektrischen und magnetischen Feldes  
 Wechselstromkreise  
 Drehstromsystem  
 Elektrische Maschinen  
 Grundlagen Leistungselektronik  
 Elektronische Bauelemente  
 Steuerungstechnik



**Intended Learning Outcomes:**

Nach der Teilnahme an der Modulveranstaltung ist der Studierende in der Lage, die Grundzüge der Elektrotechnik zu verstehen. Er kennt die Grundlagen der elektrischen und magnetischen Felder, ist vertraut mit Gleichstrom-, Wechselstrom- und Drehstromsystemen. Die Funktion und Beschreibung von elektrischen Maschinen wird grundsätzlich anhand von Beispielen erklärt. Die Grundlagen der Leistungselektronik sowie die wesentlichen Bauelemente wurden ihm vorgestellt.

**Teaching and Learning Methods:**

Das Modul besteht aus einer Vorlesung (2SWS) und einer Übung (1SWS). In der Vorlesung wird der Lernstoff mittels PowerPoint-Präsentation vermittelt. Details und Beispiele werden an der Tafel präsentiert. In der Übung werden konkrete Aufgabe und Beispiele an der Tafel vorgerechnet. Als Lernmethode wird zusätzlich zu den individuellen Methoden des Studierenden eine vertiefende Wissensbildung durch mehrmaliges Aufgabenrechnen in Übungen angestrebt.

Als Lehrmethode wird in der Vorlesungen und Übungen Frontalunterricht gehalten, in den Übungen auch Arbeitsunterricht (Aufgaben rechnen).

**Media:**

Folgende Medienformen finden Verwendung: Folienvortrag, Skriptum, Übungen, Laborführungen

**Reading List:**

" Elektrotechnik, Energietechnik  
Elpers, Meyer, Skornitzke, Willner  
Kieser Verlag, ISBN 3-8242-2022-9  
" Taschenbuch der Elektrotechnik  
Kories, Schmidt-Walter  
Verlag Harry Deutsch, ISBN 3-8171-1563-6  
" Fachkunde Elektrotechnik  
Verlag Europa-Lehrmittel, ISBN 3-8085-3020-0  
" Einführung in die Elektrotechnik  
Jötten, Zürneck  
Uni-Text, Vieweg Verlag  
" Grundlagen der Elektrotechnik  
Phillipow,  
Hüthig Verlag  
" Theoretische Elektrotechnik  
Simonyi,  
Deutscher Verlag der Wissenschaften

"

**Responsible for Module:**

Witzmann, Rolf; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Elektrotechnik (LB-MT; DBP-MT; TUM BWL) (Vorlesung mit integrierten Übungen, 3 SWS)

Almomani T [L], Stenzel D, Witzmann R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### EI74831: Project Lab Renewable and Sustainable Energy Systems | Project Lab Renewable and Sustainable Energy Systems [PropENS]

Version of module description: Gültig ab winterterm 2018/19

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Participants of the Project Lab Renewable and Sustainable Energy Systems should carry out analyses, planning and applications about renewable energy systems and their modelling. A team of 3-5 students should achieve a goal defined for the group over the duration of the lecture period of the semester within the framework of the project work. The problem definition, role distribution, idea development as well as the choice of suitable instruments, implementation and documentation are to be developed essentially independently by the group. The essential aspects of the work within the framework of the project internship (e.g. essential scientific contents, the treatment of a task as a completed project, division of the task among the group members) should be documented in a written report (volume: 15-20 pages).

In a supplementary presentation, the competence of the students to present their work in a structured way in a small seminar in front of an audience consisting of staff members of the chair and students will be examined. Overall, competencies in project work in the team as well as in documentation and presentation of the work should be demonstrated. The report is included in the grade with 40 %, the presentation and the cooperation in the team with 30%.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge about:

- Power systems
- Renewable energies (potentials, technologies)
- Matlab / Simulink

**Content:**

These are research-related and practice-oriented tasks whose topics are in line with the current research areas of the chair, such as:

- Modeling, simulation and / or regulation of energy systems
- Investigation of the potential of renewable energies
- Analysis and generation of data for energy systems
- Evaluation and interpretation of model results
- Planning and installation of plants for the use of renewable energies on the Campus Garching

**Intended Learning Outcomes:**

After successfully completing the module, the student is - depending on the topic - able to:

- recognize challenges of integrating renewable energies,
- apply and implement appropriate tools and methods to analyze, plan or regulate energy systems,
- interpret and evaluate results from applied models.

**Teaching and Learning Methods:**

Project tasks are carried out individually or preferably in groups of 2-4 students. In the process, self-dependence respectively teamwork is supported in the processing of a project task.

Depending on the topic, a literature research may be necessary. The main part of the project internship, however, is the computer-aided development of analysis and evaluation tools or the planning and execution of laboratory tests or installations.

The participants will finally have the opportunity to practice preparing and holding presentations.

**Media:**

- Application of various programs or programming languages (Matlab / Simulink, Python, etc.)
- Test benches (renewable energy conversion plants, real-time simulator, measuring instruments)
- Presentations

**Reading List:**

Konstantin, Panos: Praxisbuch Energiewirtschaft - Energieumwandlung, -transport und -beschaffung, Übertragungsnetzausbau und Kernenergieausstieg, Springer Vieweg, Springer-Verlag GmbH Deutschland, eBook ISBN 978-3-662-49823-1, DOI 10.1007/978-3-662-49823-1, Hardcover ISBN 978-3-662-49822-4

Wagner, Ulrich; Heilek, Christian (Bearb.): Nutzung regenerativer Energien (Vorlesungsskript), 10., vollständig überarbeitete Auflage, Herrsching, E & M, Energie-&-Management-Verl.-Ges., 2009, ISBN: 978-3-9805179-3-5

The Power of Transformation - Wind, Sun and the Economics of Flexible Power Systems, International Energy Agency, OECD/IEA, 2014, France, ISBN: 978 92 64 20803 2

Hillier, Frederick S., Lieberman, Gerald J.: Introduction to operations research, New York, McGraw-Hill Education, 2015, ISBN: 978-0-07-352345-3, 0-07-352345-3, 978-0-07-126767-0, 978-1-259-25318-8, 1-259-25318-X

**Responsible for Module:**

Hamacher, Thomas; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Projektpraktikum Erneuerbare und Nachhaltige Energiesysteme (Forschungspraktikum, 4 SWS)

Hamacher T, Kuhn P, Breuning L, Cadavid Isaza A, de la Rua Lope C, Halilovic S, Kerekes A, Kleeberger H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### EI7513: Ecomanagement and Life Cycle Analysis | Umweltmanagement - Ökoauditierung

Version of module description: Gültig ab summerterm 2017

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung besteht aus einer Klausur (60 min), die überprüfen soll, inwieweit die Studierenden ein Grundverständnis über Werkzeuge zum Klima- und Umweltschutz ohne Hilfsmittel abrufen können. Dazu werden verschiedene Arten von Fragen (Mehrfachantworten, offene Fragen und Rechenaufgaben) zu den in der Vorlesung behandelten Inhalten gestellt. Die Klausur wird benotet.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Folgende Module sollten vor der Teilnahme bereits erfolgreich absolviert sein:  
Vorlesung Energiesysteme

#### Content:

Die Vorlesung bietet eine Einführung in den Werkzeugkasten für eine nachhaltige Entwicklung von Unternehmen sowie übergeordnete Instrumente zum Umwelt- und Klimaschutz.

Es werden die Grundlagen zur Bilanzierung des kumulierten Energieaufwands (KEA) sowie zur Durchführung von Ökobilanzen erarbeitet. Ausgehend von den Ressourcen in der Lagerstätte werden Energieträger, Baustoffe, Metalle, Kunststoffe und andere Produkte auf Halbzeug- und Produktebene bilanziert. Für einzelne Produkte wird der ganze Lebenszyklus von der Herstellung über die Nutzungsphase bis hin zur Entsorgung bewertet. Schwerpunkt wird auf die Ökologie der Stoffströme unter Berücksichtigung von ausgewählten Prozessschritten in der Produktion gelegt. Auf Grundlage der Ökoauditverordnung werden die einzelnen Aufgaben im Umweltmanagementsystem und in der Umweltbetriebsprüfung in Unternehmen erläutert. Basierend darauf werden Kommunikationsformen wie beispielsweise Umweltberichte und Öko-

Labels vorgestellt und die Herausforderungen in Bezug auf die gesellschaftliche Akzeptanz diskutiert.

Abgeschlossen wird die Vorlesung mit einem Überblick über aktuelle klimapolitische Entwicklungen. Hierbei werden das Kyoto-Protokoll und das Übereinkommen von Paris (COP 21) vorgestellt und die Mechanismen des Emissionshandels (EU ETS) erläutert.

### **Intended Learning Outcomes:**

Der Studierende ist nach dem erfolgreichen Abschluss des Moduls zu Folgendem in der Lage:

- zu erkennen wie die Einbettung technischer Systeme in der Gesellschaft funktioniert,
- die Grundlagen des Öko-Audits zu verstehen,
- aktuelle klimapolitische Instrumente anwenden zu können,
- einfach Ökobilanzen zu erstellen und zu analysieren
- und den kumulierten Energieaufwand (KEA) und Ökobilanzen zu interpretieren und zu bewerten.

### **Teaching and Learning Methods:**

- Vortrag und Diskussion mit Präsentationen und Tafelarbeit
- Ergänzung durch Übungsaufgaben. Es werden z.B. Übungen zur Ökobilanzierung aufgestellt, CO<sub>2</sub> Emissionen berechnet, ebenso der kumulierte Energieaufwand verschiedener Produkte ermittelt.
- In einer abschließenden Exkursion wird die Theorie in der Praxis überprüft. Beispiele aus der Vorlesung werden hier aufgezeigt.

### **Media:**

Folgende Medienformen finden Verwendung:

- Rechnergestützte Präsentation für den Vortrag
- Vorlesungsskript
- Tafelarbeit

### **Reading List:**

Folgende Literatur wird empfohlen:

Kumulierter Energieaufwand für Güter und Dienstleistungen - Basis für Ökobilanzen, IfE Schriftenreihe Heft 26

### **Responsible for Module:**

Hamacher, Thomas; Prof. Dr.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Umweltmanagement - Ökoauditierung (Vorlesung, 2 SWS)

Neitz-Regett A ( Winkelmayer M )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### EI7605: Gas Sensing in Biomedical Applications | Gassensorik für biomedizinische Anwendungen [Gas sensing for biomedical applications]

Version of module description: Gültig ab summerterm 2020

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In a written exam (30 min) the achievement of the learning results is tested. Except pocket calculators no auxiliary means are allowed. The exam questions require answers in short flow text, calculations and drawings with captions.

Expected answers have the form of short, describing text (learning result 1, 2), calculations and drawings (learning result 3) or bullet point text, calculations and drawings providing the solution to problems in given case studies (learning result 4).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

basics of experimental physics, mathematics of differential equations

#### Content:

The module provides knowledge about methods to determine medically relevant parameters in breathing gas. The following chapters are outlined:

chapter 1 – physics and chemistry of the atmosphere

chapter 2 – anatomy and physiology of the respiratory tract

chapter 3 – gas exchange in lung and body tissues

chapter 4 – infections of the respiratory tract

chapter 5 – metabolites in the breathing gas

chapter 6 – the measurement of gas mass flow

chapter 7 – amperometric methods for breathing gas parameters (electrochemical)

chapter 8 – resistive methods for breathing gas parameters

chapter 9 – capacitive methods for breathing gas parameters



chapter 10 – impedance – and capacitive spectroscopy  
chapter 11 – mass spectroscopy and optical methods

**Intended Learning Outcomes:**

After attending this course the students are able to

1. describe correctly the anatomy and physiology of breathing organs and tissue respiration with the involved biomechanic and biochemical processes,
2. to distinguish pathological and healthy conditions of breathing and breathing organs,
3. to characterize sensing principles for gas flow and breathing gas parameters,
4. to assess the implementation of such sensors into medical (diagnostic) applications.

**Teaching and Learning Methods:**

The knowledge is communicated in a lecture and exemplified in case studies taken from the professional experience of the lecturer. As far as possible and reasonable these case studies will be illustrated with practical demonstrations and digital media. The students prepare the contents by examination of the recommended literature and given exercises.

**Media:**

Presentations, videos, writing board

**Reading List:**

Gerhard Wiegand, Gasesstechnik in Theorie und Praxis, Springer Verlag;  
Peter Gründler, Chemische Sensoren, Springer Verlag;  
Fan Ren and Stephen J. Pearton, Semiconductor device-based sensors for gas, chemical and biomedical applications, CRC Press;  
Sunipa Roy and Chandan Kumar Sarkan, MEMS and Nanotechnology for Gas Sensors, CRC Press;

**Responsible for Module:**

Hayden, Oliver; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Gassensorik für biomedizinische Anwendungen (Vorlesung, 2 SWS)

Hayden O [L], Scholz A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### EI80004: Sustainable Mobility | Sustainable Mobility [SuMo]

*Sustainable Mobility: Current and Future Developments*

Version of module description: Gültig ab winterterm 2018/19

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150         | <b>Self-study Hours:</b><br>105  | <b>Contact Hours:</b><br>45                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module exam consists of a 90-minute written exam, in which the students work on short word problems and multiple-choice questions on the different aspects of sustainability - especially with regard to the mobility sector. In addition, simple calculation tasks are used to check the mastery of the acquired procedures based on examples. In addition, students will use a case study to carry out the Life Cycle analysis using basic mathematical calculations. Word problems examine the understanding of the methods and the proper interpretation of results.

The exam is graded and no other documents are allowed.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamentals about:

- energy systems
- renewable energies

#### Content:

The lecture will cover the relevant questions concerning "sustainability" and "mobility" and methods to assess the sustainability of mobility systems.

- term sustainability: definition of sustainability
- tools for sustainability: (i) environmental life cycle analysis, (ii) life cycle cost analysis, (iii) social life cycle analysis and, (iv) socio-economic Input-Output Analysis.
- sustainability deficits of existing mobility: oil based system, geo-politics, CO<sub>2</sub>-emissions, particulate emissions, noise, ...
- new mobility concepts beyond technology: car sharing, inter modal transport
- electric vehicles and smart grid: current situation and challenges for sustainability.

- autonomous driving: current situation and challenges for sustainability
- other alternative fuels: current situation and challenges for sustainability

**Intended Learning Outcomes:**

After completing of the course, the student is able to:

- understand the term of sustainability
- understand the challenge that mobility represents to sustainability
- conduct a Life Cycle Analysis of different mobility options and assess the environmental impact (greenhouse gases, as well as other impacts) associated to different mobility systems from a life cycle approach
- conduct a Life Cycle Cost Analysis of different mobility options
- understand the socio-economic impacts of different systems using the macro-economic Input-Output Analysis.

**Teaching and Learning Methods:**

Case studies will be provided to the students, who will solve them using the methods learnt during the lectures

The exercises will be solved by the students during the session. The students will be encouraged to participate in the discussions

Language of instruction, English in Winter Semester and German in Summer Semester.

**Media:**

Lectures, presentations, blackboard and exercises.

**Reading List:**

Life cycle assessment student handbook

Hrsg./Bearb.: Curran, Mary Ann

Place of Publication, Publisher, Year of Publication: Hoboken, John Wiley & Sons Inc., 2015

Umfangsangabe: XI, 299 Seiten

ISBN: 978-1-119-08354-2

Life Cycle Assessment: Quantitative approaches for decisions that matter. Available at: <http://www.lcatextbook.com/>

**Responsible for Module:**

Hamacher, Thomas; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Sustainable Mobility (Übung, 1 SWS)

de la Rua Lope C, Cadavid Isaza A

Nachhaltige Mobilität (Vorlesung mit integrierten Übungen, 3 SWS)

Hamacher T, de la Rua Lope C, Cadavid Isaza A

Sustainable Mobility (Vorlesung, 2 SWS)

Hamacher T, de la Rua Lope C, Cadavid Isaza A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### MW0219: Project Management for Engineers | Projektmanagement für Ingenieure

Version of module description: Gültig ab winterterm 2011/12

|                                         |                            |                                  |                                      |
|-----------------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Prüfung besteht zu ca. 40% aus Kurzfragen, in denen direkt das zu erlernende Wissen abgefragt wird. Im Rest der Prüfung muss dieses Wissen praktisch in kleinen Fallbeispielen angewendet werden. Zugelassene Hilfsmittel: Taschenrechner, nicht elektronisches Wörterbuch

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Die Lerninhalte bauen auf keinen anderen Vorlesungen auf, setzen aber ein breites, allgemeines Wissen voraus.

#### Content:

In diesem Modul wird das Wissen vermittelt, um Projektmanagement praktisch durchzuführen.

Im Wesentlichen werden die folgenden Hauptaufgaben des Projektmanagements behandelt:

Zieldefinition ("Was sind Ziele?", "Wie werden Ziele formuliert?")

Projektablauf (Meilensteinplan, Zwischenergebnisse)

Projektorganisation (Projektleiter, Projektteam, Betroffene, Beteiligte)

Projektplanung (Qualität, Leistung, Kosten und Termine)

Projektsteuerung (Störungsbehandlung, Reporting) und

Führung und Zusammenarbeit (Teamarbeit, Konfliktbewältigung)

#### Intended Learning Outcomes:

Nach der Teilnahme an den Lehrveranstaltungen des Moduls kennen die Studierenden die Grundlagen, um Projekte zu planen, zu steuern und abzuschließen.

**Teaching and Learning Methods:**

- Eigenstudium der Fachbegriffe und grundlegenden Zusammenhänge
- Lösen von Fragen/Aufgaben zum Inhalt der Lehrveranstaltung anhand von Beispielen; Analyse und Diskussion der Ergebnisse
- Ergänzen des Lehrstoffes durch Studium der empfohlenen Literatur
- Übungsaufgaben werden den Studierenden in der Übungsstunde zur Verfügung gestellt und anschließend werden die Ergebnisse hinsichtlich ihrer Plausibilität diskutiert
- Eingehende Diskussion von Fallbeispielen, um die theoretischen Grundlagen zu vertiefen

**Media:**

Die Inhalte der Vorlesung werden zum Einen mit Hilfe einer PowerPoint-Präsentation vorgetragen und zum Anderen zusammen mit den Studierenden an einem Flip-Chart erarbeitet. Dadurch werden die Studierenden aktiv in die Vorlesung mit eingebunden. Die Übung erfolgt anhand einer erklärenden PowerPoint-Präsentation mit vielen Fallbeispielen und Übungsaufgaben. Begleitend zu der Vorlesung kann ein Skript erworben werden, indem die PowerPoint-Präsentation enthalten ist.

**Reading List:**

Eine Foliensammlung zu den Lehrveranstaltungen steht beim Skriptenverkauf zur Verfügung. Die in der Vorlesung erstellten Flip-Charts werden zum Download ins Internet gestellt. Die Folien und Aufgaben aus der Übung stehen auf der Homepage der Vorlesung zum Download zur Verfügung.

**Responsible for Module:**

Zäh, Michael; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Projektmanagement für Ingenieure (Vorlesung, 2 SWS)

Göttel P, Götz D

Projektmanagement für Ingenieure Übung (Übung, 1 SWS)

Göttel P, Götz D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### MW1535: Introduction to Patent, Trademark and Design Law for Engineers | Patent-, Marken- und Musterrecht für Ingenieure: Eine Einführung

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In a written exam (60 min.) the taught content have to be applied to different questions.

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

This lecture is aimed in particular at engineering students and is intended to provide a basic understanding of industrial property rights. The aim of the course is to provide an overview of the most important industrial property rights, i.e. patent, trademark and design, and to deal in depth with the topics of obtaining, defending and enforcing a technical property right using the example of the patent. The lecture also covers the topics of copyright law, customs regulations, due diligence in Mergers & Acquisitions.

#### Intended Learning Outcomes:

The aim of the course is to provide an overview of the most important industrial property rights, i.e. patent, trademark and design, and to deal in depth with the topics of obtaining, defending and enforcing a technical property right using the example of the patent.

#### Teaching and Learning Methods:

In the lecture, the course contents are taught by means of lecture and presentation. Problems and topics from practice are presented as examples. The slides and further information are made available to the students online via the e-learning portal.

**Media:**

Lecture, presentation, handouts, online teaching materials, videos

**Reading List:**

Ilzhöfer/Engels, Patent-, Marken- und Urheberrecht, 8. Auflage, Verlag Vahlen, 2010;  
Beck-Texte, 11. Auflage, Patent- und MusterR, dtv, 2011;  
Beck-Texte, 31. Auflage, Wettbewerbsrecht, Markenrecht und Kartellrecht, dtv, 2010;  
Benkard, Kommentar zum Patentgesetz, 10. Auflage, Verlag C. H. Beck, 2006;  
Schulte, Kommentar zum Patentgesetz, 8. Auflage, Heymanns Verlag, 2008;  
Ingerl/Rohnke, Kommentar zum MarkenG, 3. Auflage, Verlag C. H. Beck, 2010;  
Ströbele/Hacker, Kommentar zum MarkenG, 10. Auflage, Heymanns Verlag, 2009  
Patentgesetz (PatG), Gebrauchsmustergesetz (GebrMG), Designgesetz (DesignG)

**Responsible for Module:**

Mela, Petra; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Patent-, Marken- und Musterrecht für Ingenieure: Eine Einführung (Vorlesung, 2 SWS)  
Mela P [L], Wende C, Müller K, Mela P, Mansi S, Ahrens M  
For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### MW2149: Introduction to Wind Energy | Introduction to Wind Energy

Version of module description: Gültig ab summerterm 2022

|                                  |                             |                                  |                                      |
|----------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5            | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a written exam (90 minutes). The purpose of the exam is for students to demonstrate, within limited time, their ability in:

- Explaining the concepts that were covered during the lectures. This implies explaining, among the others, the main physical principles underlying the wind turbine aerodynamics and control, as well as the main features of the wind resource or the distinguish characteristics of offshore wind turbines.
- Solving problems that require using equations that were introduced during the lectures. This includes, among the others, computing the power and other operational parameters of a wind turbine under different environmental conditions, or determining the forces exerted by a section of a wind turbine blade.

Tools allowed in the exam: writing utensils, ruler, scientific non-programmable calculator and a note-sheet

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in engineering mechanics and aerodynamics.

#### Content:

- " Introduction to wind energy, the wind resource and its characteristics.
- " Wind turbine types, configurations, components, design of machines and wind farms.
- " Wind turbine aerodynamics.
- " Dynamics, aeroservoelasticity and control of wind turbines.
- " Introduction to off-shore wind, the off-shore environment, support structures, dynamics.
- " Introduction to electrical systems and grid integration.

**Intended Learning Outcomes:**

After participating to the module, students will be able to explain the basic principles underlying the energy conversion process from wind, with a particular emphasis on a multidisciplinary view of the problem. Furthermore, they will be able to master basic concepts concerning the aerodynamics, dynamics and control of wind turbines, and to apply them for the design and operation of wind turbines. Finally, students will be able to evaluate the best solutions for the conversion of mechanical energy into electrical energy, and how to best integrate both onshore and offshore wind farm power to the existing electrical grid.

**Teaching and Learning Methods:**

The module consists of both lectures and exercises. During the lectures, students are instructed in a teacher-centered style. This means, the main aspects of wind energy are presented by way of talks or presentations. Materials will be provided in an appropriate manner in time. With the information given, student learn to explain the basic principles underlying the energy conversion process from wind to electricity, with a particular emphasis on a multidisciplinary view of the problem.

The exercises are held in a student-centered way. Exercises are offered in advance for download , which will be worked through together in the exercise. The joint discussion and development of the solution are the basic principle of the exercises. The students are explicitly encouraged to ask questions and to express their solution approaches. With this, the students learn to apply basic concepts related to all principal aspects of wind energy technology, thus including the aerodynamics, dynamics and control of wind turbines, as well as their design and operation.

**Media:**

The following kinds of media are used:

- Class room lectures
- Lecture notes (handouts)
- Exercises with solutions as download

**Reading List:**

Course material will be provided by the instructor.

Additional recommended literature:

" T. Burton, N. Jenkins, D. Sharpe, E. Bossanyi, Wind Energy Handbook, Wiley, 2011.

" J. F. Manwell, J.G. McGowan, A.L. Rogers, Wind Energy Explained, Theory, Design and Application, Wiley, 2012.

**Responsible for Module:**

Bottasso, Carlo; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Introduction to Wind Energy (MW) (Übung, 2 SWS)

Bottasso C [L], Aktan H, Campagnolo F

Introduction to Wind Energy (MW) (Vorlesung, 2 SWS)

Bottasso C [L], Aktan H, Campagnolo F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### MW2152: Modeling, Control and Design of Wind Energy Systems | Modeling, Control and Design of Wind Energy Systems

Version of module description: Gültig ab winterterm 2013/14

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>105  | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Grading is based on a written exam, of a duration 90 min. Students should demonstrate their knowledge of the principal topics of the course, including wind turbine aerodynamics, aeroelasticity, regulation & control, simulation and design. The exam is composed of about 10-15 questions, each one worth a certain number of points, for a total of 100 points. Questions will include multiple-choice answers, open questions and exercises. Detailed instructions on the exam will be given both at the beginning and at the end of the course. A review lecture will be offered at the end of the course to highlight the main concepts and help students prepare for the exam.

No aids are allowed during the exam, i.e no notes nor calculators, PCs, smartphones, etc.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in engineering mechanics and aerodynamics.

#### Content:

The course offers a broad introduction to the engineering principles underlying the operation of wind turbines, as well as their design. The course is organized in the following five main modules:

" Introduction: introduction to wind energy, and overview of wind energy systems and wind turbines; the wind resource and its characteristics; anatomy of a modern wind turbine; wind turbine components; electrical aspects.

" Wind turbine aerodynamics: overview of rotor aerodynamics; one-dimensional momentum theory and Betz limit; wake swirl; airfoils; blade element momentum theory, dynamic inflow; unsteady corrections, blade tip and hub losses, dynamic stall, stall delay and three-dimensional effects; deterministic and stochastic wind models.

" Dynamics and aeroservoelasticity: rigid and elastic flapping and lagging blade; the rotor as a filter, aerodynamic damping, flutter, limit cycle oscillations; loads; stability analysis; aeroservoelastic models of wind turbines; aeroservohydroelastic models for off-shore applications.

" Wind turbine control: overview and architecture of wind turbine control systems; on-board sensors; supervisory control; regulation strategies; trimmers, load-reducing control, dampers; load and wind observers.

" Wind turbine design: overview of design criteria and certification guidelines; aerodynamic design; structural design; design and choice of sub-systems and components.

### **Intended Learning Outcomes:**

After successfully completing the course, students will have an understanding of all main physical processes underlying the energy conversion process from wind. In addition, they will be able to apply their knowledge for giving qualitative explanations of key phenomena and for making some relevant quantitative predictions. For example, students will be able to analyze wind turbine performance and dynamics response, and to demonstrate the main strategies used for controlling these machines over their complete operating range. A specific goal of the course is to provide students with a multidisciplinary vision on the physics of wind energy systems, and to make them able to apply the explained methods to relevant problems. A particular emphasis will be placed on design, so that students will be able to evaluate the effects of design choices on the cost of energy.

### **Teaching and Learning Methods:**

The course includes teaching lectures, which cover all theoretical content of the course and that are delivered with a teacher-centered style. The lectures are delivered with the help of slides, which include text, equations, figures, sketches and occasionally movies, as necessary in order to explain specific concepts or physical processes. Relevant examples from real-life wind energy applications will be given, whenever necessary or useful. The lecturer will annotate the slides or use the blackboard to help clarify some specific aspects, as necessary to ensure clarity and completeness of exposition. Review of background material is offered at the beginning of the course, to ensure that all students have the necessary knowledge and terminology.

The course also includes exercise sessions, whose role is to consolidate and deepen the understanding of topics presented in the teaching lectures. Exercise sessions are typically initiated with a short review (given by the teacher with the help of dedicated slides) of the theory or methods explained in the lecture sessions. After the review, exercise sessions are continued with student-centered work, where students solve practical problems (for example dealing with the formulation of regulation strategies, the assessment of the vibratory behavior of a rotor, or the analysis of its performance) using computer programs. Students are encouraged to use their own individual learning methods, and to take advantage of the exercise sessions to reinforce and ease the understanding of the course main topics.

All course content is described and explained in self-contained lecture notes and support material, which are made available to the students at the beginning of the course. The course material

covers also the exercise sessions, and it is complemented by computer programs and all necessary data.

**Media:**

The following kinds of media are used:

- Class room lectures
- Lecture notes (handouts)
- Exercises with solutions as download

**Reading List:**

Course material will be provided by the instructor.

Additional recommended literature:

" T. Burton, N. Jenkins, D. Sharpe, E. Bossanyi, Wind Energy Handbook, Wiley, 2011.

" J. F. Manwell, J.G. McGowan, A.L. Rogers, Wind Energy Explained, Theory, Design and Application, Wiley, 2012.

**Responsible for Module:**

Bottasso, Carlo; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Modeling, Control and Design of Wind Energy Systems (Vorlesung, 2 SWS)

Bottasso C [L], Anand A, Bottasso C, Mühle F, von Braunbehrens R

Modeling, Control and Design of Wind Energy Systems (Übung, 1 SWS)

Bottasso C [L], Anand A, Mühle F, von Braunbehrens R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### POL23200: Environmental Politics in International Comparison | Umweltpolitik im internationalen Vergleich

Version of module description: Gültig ab winterterm 2016/17

|                                  |                            |                                  |                                      |
|----------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6            | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung ist schriftlich oder im Fall, dass sie in Form einer Gruppenarbeit erbracht wird, mündlich und schriftlich. Sie wird entweder in Form von zwei Seminararbeiten (je Seminar eine im Umfang von ca. 10 Seiten), in Form einer Hausarbeit (Umfang ca. 20 Seiten), oder in Form der Teilnahme an einem Rollenspiel, inklusiv schriftlicher Vorbereitungsarbeit, erbracht. Während die Seminararbeiten seminarbegleitend im Laufe der Vorlesungszeit erstellt werden, kann die Hausarbeit auch in der darauffolgenden vorlesungsfreien Zeit geschrieben werden. Bei der Ausgestaltung der Gruppenarbeit wird die schriftliche Vorbereitungsarbeit im Lauf des Seminars erbracht. Das Thema der jeweiligen Seminararbeit wird in Absprache mit dem Seminarleiter entwickelt und umfasst einen spezifischen Themenbereich des Seminars, der im Rahmen der Seminararbeit, angeleitet durch eine präzise Fragestellung, vertieft analysiert wird. Im Rahmen der Hausarbeit wird ein breiter angelegtes Thema bearbeitet, das ebenfalls zumindest in einem der Seminare behandelt wurde und in Form einer vertieften Ausarbeitung, wiederum angeleitet durch eine präzise Fragestellung, analysiert wird. Die Studierenden haben bei der Hausarbeit die Möglichkeit zu wählen, in welchem Seminar sie diese ablegen möchten. Als Studienleistung wird in beiden Seminaren von jedem Studierenden die Vorbereitung und Präsentation eines Referats im Umfang von mindestens 20 Minuten zu einem Sitzungsthema verlangt. Gruppenreferate von bis zu drei Studierenden sind möglich.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

**Content:**

The module introduces environmental politics from an international comparative perspective. The central institutions, actors, processes, content and outcomes of environmental politics will be considered and analysed comparatively and theoretically. A focus will be on policy conflicts and problems, governance instruments (implementation challenges) and actor constellations. The multiple levels of environmental policy making in the European and international context will also be considered. Finally, the module will consider which factors influence the environmental policies of a country as well as the factors contributing to the successes and failures of pioneer and laggard states.

**Intended Learning Outcomes:**

After participating in the module, students will be able to identify key concepts and theories of environmental policy; to distinguish among different theoretical approaches to environmental politics research; to apply methods of comparative analysis to various environmental politics areas; to compare internationally the institutions, actor constellations, processes and outcomes of national environmental politics, and to evaluate environmental policy outcomes from a comparative perspective.

**Teaching and Learning Methods:**

The module is offered in the form of two seminars, each dealing with different, but complementary thematic areas of the module. The best approach to obtaining a deeper understanding of a module's topics through independent work and general discussion will determine the form of the seminar. Seminars offer the opportunity for both an instructor's direct input and a wide variety of active learning methods. During the seminars, deep discussions and students' inputs will help in understanding the material presented by the instructor. Concrete examples will be used to practice, analyse, and evaluate the material which has been presented. The presentations developed and given by the students and ensuing discussions of those presentations will also contribute to this understanding.

**Media:**

Course reserve readings, Online Reader, Whiteboard, PowerPoint

**Reading List:**

Katharina Holzinger, Thomas Sommerer, Was verursacht die Aufwärtsspirale in der Umweltpolitik? Der Einfluss internationaler Harmonisierung auf nationale Umweltstandards. Österreichische Zeitschrift für Politikwissenschaft 41(1), 53-72 2012. Martin Jänicke, Helmut Weidner (Hg.), Successful Environmental Policy. A Critical Evaluation of 24 Cases. Berlin 1995. Wolfgang Muno, Umweltpolitik, in: Hans-Joachim Lauth (Hg.): Vergleichende Regierungslehre. Eine Einführung. Wiesbaden, 349-372 2010. Miranda A. Schreurs, Environmental Politics in Japan, Germany, and the United States. Cambridge 2002. Paul Steinberg and Stacy VanDeveer eds., Comparative Environmental Politics: Theory, Practice, and Prospects (Cambridge: MIT Press 2012).

**Responsible for Module:**

Prof. Dr. Miranda Schreurs



**Courses (Type of course, Weekly hours per semester), Instructor:**

(POL23200) Umweltpolitik im internationalen Vergleich (- Seminar 2) (Seminar, 2 SWS)

Schreurs M ( Mohammed N )

(POL23200) Umweltpolitik im internationalen Vergleich (- Seminar 1) (Seminar, 2 SWS)

Schreurs M ( Mohammed N )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### POL40100: Introductory Lecture: Politics and Technology | Ringvorlesung: Politics & Technology

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Current notice in view of the restricted presence operation due to the CoViD19 pandemic: If the general conditions (hygiene, distance rules, etc.) for a presence test are not available, the planned form of examination can be switched to electronic (remote) testing in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at the latest 14 days before the examination date by the examiner after consultation with the responsible examination board.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

None

#### Content:

The module is intended as an introduction to the questions and research being addressed in the main thematic areas of the master's program: big transformations and their environmental, technological, and social dimensions; democracy in a digital age; and global governance, ethics and technology. The links between these areas and research areas found in the TUM, such as economics and policy, digital technologies, social responsibility and corporate governance, and urbanization, mobility, and energy will be explained.

#### Intended Learning Outcomes:

After participating in the module, students will have a strong overview of the kinds of research questions being addressed by faculty in the HfP. They will be knowledgeable about some of the big questions driving the study of politics and research methods and theories which are used to address those questions: What role does the state play in technological innovation? How well

do different political systems address major challenges like climate change, biodiversity loss, and ocean acidification? How is support for democracy impacted by growing economic inequalities? How might new technologies alter forms of societal participation in governance processes?

**Teaching and Learning Methods:**

The module is offered in the form of two seminars, each dealing with different, but complementary thematic areas. One will focus on big questions for politics in a world of rapidly changing technologies, globalization, migration, and challenges to democracy. The other will look at major policy problems (the Energiewende, Resource depletion, urbanization) and how they are being addressed by governments, industrial actors, and civil society.

**Media:**

Online-Reader, PowerPoint

**Reading List:**

A reader of seminar texts with up-to-date and cutting edge scientific literature will be made available at the start of the semester.

**Responsible for Module:**

Schreurs, Miranda; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

(POL40100) Introduction to Politics, Technology & Sustainability (Vorlesung, 4 SWS)

Schreurs M ( Mohammed N, Schmid H )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### POL60700: Democracy in the Digital Age | Democracy in the Digital Age

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module grade is based on a written examination in the form of a seminar paper (13 – 15 pages). Through their seminar paper, students will document to which extent they have gained a foundational understanding in the area of Democracies in the Digital Age and whether they are able to apply the introduced theories and approaches to analyze specific policy problems. The seminar paper is accompanied by a presentation (15 - 30 min) to test the communicative competence of presenting scientific topics to an audience. The presentation must be supplemented by a short-written handout. The module grade consists of the seminar paper (80%) and the presentation (20%).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

-

#### Content:

This module provides a foundational introduction to the area of democracies in the digital age, focusing on the benefits and challenges of digital technologies for democracies. This includes seminal theories and approaches as well as their application to current policy areas in the digital age. For example, students will gain a deeper understanding in theory and practice in a comparative context of the influence of digital information and communication technologies in elections, how they can disrupt democracies, or whether e-governance might lead towards a digital democracy.

#### Intended Learning Outcomes:

Upon successful completion of this module, students will understand foundational theories and approaches in the area of democracies in the digital age. They will further be able to apply the

introduced theories and approaches to analyze complex contemporary challenges of democracies manifested through these new information and communication technologies.

**Teaching and Learning Methods:**

The module consists of two seminars. This setting allows for an intensive discussion of specific theories and policy areas of Digital Democracy and it is meant to encourage in-depth exploration of the module's topics and independent study of the scientific literature.

**Media:**

Scientific literature, PowerPoint, Reader

**Reading List:**

Mounk, Y. (2018): The people vs. democracy: why our freedom is in danger and how to save it, Harvard University Press.

A reader of seminar texts will be made available at the start of the semester.

**Responsible for Module:**

da Conceicao-Heldt, Eugenia; Prof. Dr. phil.

**Courses (Type of course, Weekly hours per semester), Instructor:**

(POL60700) Democracy in the Digital Age (Seminar 1 + 2) (Seminar, 4 SWS)  
Csehi R ( Müller T )

(POL60700) Democracy in the Digital Age (Seminar 1 + 2) (Seminar, 4 SWS)  
Csehi R ( Müller T ), Gad N

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### POL62200: Energy Transformation | Energy Transformation

Version of module description: Gültig ab winterterm 2017/18

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

For this module, evaluations will be based on written work and a presentation. The written assignment for the module will be of a length of approximately 20-25 pages. The topic of the module paper is to be developed in consultation with the seminar leaders and will deal with a specific topic of the seminar (energy transformation) and its technological, political, and social dimensions. The paper will be introduced with a precise question and then analyzed in depth. The methodology of research needs to be indicated and a comprehensive bibliography included. Students will be expected to prepare and give a presentation of at least 20 minutes tied to a session topic. Group presentations of up to three students are possible as long as individual contributions are discernible.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Ring lecture „Politics & Technology“

#### Content:

For a variety of reasons, including energy security, environment and climate concerns, and the potential to develop new technologies and processes, cities, countries and entire regions are pursuing low-carbon energy transitions. Understandings of what the best approach to a low carbon energy transition is, however, vary widely. The extent to which energy transitions are occurring in various sectors (power, heating/cooling, transportation) differs significantly. Why is this the case? What factors support or inhibit the scaling-up of policy solutions? What are the challenges associated with large scale energy system transformations? How similar or different are energy system transformations to other major transformations which have occurred in the past or which may need to occur in the future? This module will consider these and other questions in the context of Germany, at the European level and internationally.

**Intended Learning Outcomes:**

After participating in this module, students will understand the arguments underpinning decisions to pursue low carbon energy transitions, how low carbon energy transitions are affected by broader economic, technological, and political factors, and the ways in which actors at the local, national, or international level may act to promote or inhibit change. They will have gained insights into system transformation thinking, understand aspects of the production, distribution and utilization of energy and their interplay; apply methods of comparative policy analysis to energy policy in different political systems; be able to identify challenges of policy-making in national politics and the European multi-level system; to critically analyze energy policy in Germany, Europe, and internationally (for example in China, Japan, India, the United States as well as at the global level); to analyze the factors determining German, European, and international energy politics, and to evaluate the effects of different energy policy governance instruments (like legal regulation, planning, incentive design, taxes, subsidies, etc.).

**Teaching and Learning Methods:**

The module is offered in the form of two seminars, each dealing with different, but complementary thematic areas. One will be focused more on the transition of the energy systems in Germany and Europe while the other will concentrate more on the international and global level. To obtain a deeper understanding of the module's topics a combination of independent work and general discussion will be used in the seminar. Seminars will include both direct input from the instructor and a wide variety of active learning methods. During the seminars, there will be in-depth discussions and inputs by students. Concrete examples will be used to practice, analyze, and evaluate the material which has been presented. Both the technical and scientific aspects of issues as well as their political and social implications will be discussed. The presentations developed and given by the students and ensuing discussions will contribute to the students' understanding of the seminar materials and instructor's inputs.

**Media:**

Online-Reader, PowerPoint

**Reading List:**

A reader of seminar texts with up-to-date and cutting edge scientific literature will be made available at the start of the semester.

**Responsible for Module:**

Schreurs, Miranda; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

(POL62200) Energy Transformation (Seminar 1 + 2) (Seminar, 4 SWS)

Cetkovic S ( Mohammed N )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### POL62400: Environment and Climate Transformation | Environment and Climate Transformation

Version of module description: Gültig ab winterterm 2017/18

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

For this module, evaluations will be based on written work and in cases of simulations will also be participative. Written assignments will entail either two seminar papers (one paper per seminar each of about 10 pages), a term paper of about 20 pages, or participation in a simulation, including written preparatory work therefore. Seminar papers are to be written during the semester while term papers can also be written in the time between semesters. In the case of simulations, the written preparatory work is to be done during the seminar. The topic of the seminar papers is to be developed in consultation with the seminar leader and should deal with a specific topic of the seminar, which is introduced with a precise question and then analyzed in depth. For a term paper, a broader topic which has been covered in at least one of the seminars is to be addressed. The term paper should be guided by a precise question which is then analyzed in depth. Students have the opportunity to choose for which seminar they wish to prepare a term paper. As course work, students will be expected to prepare and make a presentation of at least 20 minutes in both courses on a theme being discussed in class. Group presentations of up to three students are possible.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Ring lecture „Politics & Technology“

#### Content:

Global climate change, biodiversity loss, resource depletion, ocean acidification, and land degradation are some of the many environmental problems which have potentially grave consequences for humanity. These consequences are noticeable at the local, regional, national and international levels. This module considers both the impacts of environmental problems on



today's societies as well as the potential implications for future generations. It also considers various technological-and social responses to these problems at the regional, national and international level.

### **Intended Learning Outcomes:**

This module will help students identify key concepts and theories tied to environmental and climate politics at the local, national, European and global levels, to understand decision making processes, and to work with different environmental policy instruments (for example legal regulation, planning, incentive design, taxes, subsidies, etc.). Students will be able to recognize and make use of different negotiation strategies. They will be able to consider the strengths and weakness of a variety of regulatory and non-regulatory governance instruments, develop leadership skills, understand the importance of issue framing, and consider the importance of coalitions. They will gain an awareness of different theoretical and methodological approaches to environmental and climate politics research and will be able to apply methods of comparative analysis to environmental and climate politics at the regional, national, and international levels. The inter- and intra-generational justice aspects of environmental and climate policy making (or lack of action) will be considered along with the implications of different technological, economic, and social solutions. The course will be global in its scope examining both developing, transitioning, and technologically developed countries.

### **Teaching and Learning Methods:**

The module is offered in the form of two seminars, each dealing with different, but complementary thematic areas. One should be focused more on technological, social, and intergenerational justice implications of environmental, energy, and climate decision making while in the other seminar the students have the opportunity to model political decision-making and negotiations. As a goal of the module is to strengthen students' negotiating skills, in-class simulations will be developed (e.g. of global climate or biodiversity negotiations or of negotiations among European countries). This may include a weekend or alternative extra-long session to allow for a full-length negotiation. Seminars will include both direct input from the instructor and modelling of domestic and international negotiations. Active participation in seminars will be essential. In-class negotiations or decision making simulations will be complemented by written reflection pieces. The presentations developed and given by the students during and after simulation exercises will contribute to the students' understanding of how decision making and negotiations function.

### **Media:**

Online-Reader, PowerPoint

### **Reading List:**

A reader of seminar texts with up-to-date and cutting edge scientific literature will be made available at the start of the semester.

### **Responsible for Module:**

Schreurs, Miranda; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

(POL62400) Environment and Climate Transformation (- Seminar 1) (Seminar, 2 SWS)  
Ohlhorst D ( Mohammed N, Schreurs M )

(POL62400) Environment and Climate Transformation (- Seminar 2) (Seminar, 2 SWS)  
Schreurs M ( Mohammed N, Schreurs M )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### POL62500: The Ethics and Politics of Existential Global Risks | The Ethics and Politics of Existential Global Risks

Version of module description: Gültig ab winterterm 2017/18

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Students will write an advanced research paper (18-20 pages) in one of the seminars, which contains independent research, and which is handed in at the end of the term break after the semester in which the module is taught. Through this research paper, they show their ability to understand a complex and cutting-edge topic in political theory, to identify open research questions, to formulate a research agenda, to collect literature and to research material, and to compose a paper that is well-argued and up to current standards of research. During the semester students compose three written pieces: two short papers (2-3 pages) responding to a given week's reading, and (before the end of the semester) an initial research plan (2 pages) containing their research question and outlining their intentions for the final paper. The average grade of these pieces and the grade of the final research paper multiplied by three will form a sum; this sum will be divided by four to arrive at the final grade. Students may be offered the opportunity to receive a grade bonus of 0,3 for oral contributions, e.g. presentations; details will be announced at the beginning of each seminar.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Political Theory I and II

#### Content:

Seminar 1, "Uncertainty, knowledge, responsibility" discusses basic normative questions about how human beings should deal responsibly with uncertainty and risk. Themes may include: how do moral theories, such as consequentialism, deontology and virtue ethics, differ with regard to their ability to provide guidance in situations of uncertainty and/or high risks; what is the responsibility of experts as bearers of knowledge? Seminar 2, "Climate Ethics and Climate Justice", introduces

students to the normative dimensions of climate change. Themes may include: the individual and the political level of responsibility, the specific features of climate change as a global commons problem; ethical, political and technological proposals for responding to climate change; the ethical permissibility and political feasibility of climate engineering. NOTE: Instead of taking these two seminars, and depending on teaching capacities, students might be given permission to replace one of them with a seminar on related themes from a different module.

### **Intended Learning Outcomes:**

In this module students bring together their previously acquired knowledge of debates in political theory as well as knowledge of technological and political developments in order to become able to cogently analyze selected questions of the ethics and politics of existential global risks, with a special focus on technical and environmental risks. Human agency, including political agency, takes place not only under conditions of quantifiable risk, but also under conditions of fundamental, and unquantifiable uncertainty. What does it mean to act responsibly under such circumstances? While much technology is based on the Baconian idea of subjecting nature to human control by understanding its laws, technological developments have contributing to creating new risks, both for nature and for the human race. In the module, students will learn to analyze the normative dimensions of actions under risk and uncertainty, with a special focus on climate risks and technological responses to it. Questions include: What kind of responsibility comes with (technical) knowledge? Does the fact that we may not know the exact effects of our behavior diminish our moral responsibility? What forms of climate engineering are ethically justifiable?

### **Teaching and Learning Methods:**

This module consists of seminar courses and substantial independent research on the part of students. Students submit three pieces of written work throughout the semester: two response papers addressing problems raised in assigned readings, as well as a preliminary research plan for the final paper at the end of the semester. The seminar sessions are discussion-based and highly interactive, and will combine working through complex political issues and a discussion of student response papers.

### **Media:**

Literature, Powerpoint, Whiteboard

### **Reading List:**

Literature will be provided on moodle. Exemplary texts include: Knight, Frank. Risk, Uncertainty, and Profits. Mineola: Dover Publications (2006 [1921]), Young, Iris Marion. 2011. Responsibility for Justice. Oxford: Oxford University Press, Weick, Karl E., and Kathleen M. Sutcliffe. 2001. Managing the Unexpected. San Francisco: Jossey-Baas, Oakley, Justin and Dean Cocking. 2002. Virtue Ethics and Professional Roles. Cambridge: Cambridge University Press, Jamieson, Dale. 2008. Ethics and the Environment: An Introduction. Cambridge: Cambridge University Press, Gardiner, Stephen et al. (eds.). 2010. Climate Ethics: Essential Readings. Oxford: Oxford University Press. Hardin, Garrett. 1968. "The Tragedy of the Commons." Science. Mulgan, Tim. 2011. Ethics for a Broken World: Imagining Philosophy After Catastrophe. Montreal / Kingston-Itacha: McGill-Queen's University Press.

**Responsible for Module:**

Schreurs, Miranda; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

(POL62500) The Ethics and Politics of Existential Global Risks (Part 1) (Seminar, 2 SWS)

Ohlhorst D ( Mohammed N )

(POL62500) The Ethics and Politics of Existential Global Risks (Part 2) (Seminar, 2 SWS)

Ohlhorst D ( Mohammed N, Schmid H )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### POL70070: Ethics of Technology | Ethics of Technology

Version of module description: Gültig ab winterterm 2017/18

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination will be held in form of a presentation (60 minutes). In this presentation, a relevant techno-ethical topic will be condensed and effectively communicated in limited time with the help of an adequate visualisation to a willing audience. With the presentation, students will also prove their ability to lead a critical discourse and show that they are able to react to questions and impulses.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Knowledge about foundations of ethics/business ethics

#### Content:

1. Which ethical problems arise from human-machine interactions?; 2. How should human-machine interactions be designed from an ethical perspective?; 3. Do technical systems carry responsibility?; 4. What is "mindless morality"?; 5. Are the ethical limits to progressive thinking?; 6. How can consequences of technologies be evaluated?; 7. How can problems of an ethics of technology be investigated empirically?; 8. What do social-science experiments achieve for an ethics of technology?; 9. What causes societal resistance against technological progress?; 10. How should one deal with concerns about technological progress?

#### Intended Learning Outcomes:

1. Students are able to deal critically with the ethical implications of technological developments; 2. Students learn to argue consistently against the background of an ethical theory; 3. Students are able to apply basic ethical concepts on problems of evaluating technologies; 4. Students acquire the ability to hold a scientific presentation; 5. Students practice their ability to write down scientific arguments

**Teaching and Learning Methods:**

Seminar 1:

Seminar units by the instructors to transport theoretical foundations; group discussions to train students' argumentation; online quizzes to regularly monitor students' learning progress;

Seminar 2:

presentations by students to train their ability to hold scientific talks; moderation of scientific discussions evolving around the presentations; preparation of case studies to practice the application of basic ethical concepts to concrete examples

**Media:**

Moodle, whiteboard, exercise sheets, flipchart, PowerPoint, films

**Reading List:**

Franssen, Maarten; Lokhorst, Gert-Jan; van de Poel, Ibo (2013): Philosophy of Technology, in: Zalta, Edward N.: Stanford Encyclopedia of Philosophy, available at:

<https://plato.stanford.edu/entries/technology/>

Institute of Electrical and Electronic Engineers (IEEE) (2017): Ethically Aligned Design: A Vision for Prioritizing Human Well-being with Autonomous and Intelligent Systems, Version 2, available at: [http://standards.ieee.org/develop/indconn/ec/autonomous\\_systems.html](http://standards.ieee.org/develop/indconn/ec/autonomous_systems.html)

Peterson, Martin (2017): The Ethics of Technology: A Geometric Analysis of Five Moral Principles, Oxford University Press.

**Responsible for Module:**

Lütge, Christoph; Prof. Dr. phil.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0211: Chinese A2.1 | Chinesisch A2.1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft.

Die Klausur beinhaltet Fragen zur Anwendung von Wortschatz und Grammatik, zu Lese- und Hörverstehen sowie Aufgaben zur freien Textproduktion in Schriftzeichen/Pinyin und wird in Form von Präsenzprüfungen oder (Portfolio-)Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt.

Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. In diesem Fall beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bestanden Abschlussklausur A1.2 oder gleichwertige Vorkenntnisse

#### Content:

Der Schwerpunkt dieses Moduls liegt in der Verfeinerung der Sprachkenntnisse. Kombination von verschiedenen Satzelementen wie Orts- und Zeitangaben sowie Äußerung von persönlichen Meinungen werden in diesem Modul erarbeitet.

#### Intended Learning Outcomes:

Die Studierenden sind nach der Teilnahme an der Modulveranstaltung in der Lage, genauere Aussagen zu machen und komplexere Äußerungen zu formulieren.

#### Teaching and Learning Methods:

Einzelarbeit, Partnerarbeit, Gruppenarbeit



Hausaufgaben zur Vor- und Nachbearbeitung sind freiwillig und fördern die Beherrschung der Zielsprache.

**Media:**

Lehrbuch, Übungsblätter, Audio-CD und multimedial gestützte Lehr- und Lernmaterialien

**Reading List:**

wird in der Veranstaltung bekanntgegeben

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Chinesisch A2.1 (Seminar, 2 SWS)

Kralle J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0212: Chinese A2.2 | Chinesisch A2.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft.

Die Klausur beinhaltet Fragen zur Anwendung von Wortschatz und Grammatik, zu Lese- und Hörverstehen sowie Aufgaben zur freien Textproduktion in Schriftzeichen/Pinyin und wird in Form von Präsenzprüfungen oder (Portfolio-)Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt.

Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. In diesem Fall beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Abschlussklausur A2.1 oder gleichwertige Vorkenntnisse

#### Content:

In diesem Modul werden komplexere Satzstrukturen erarbeitet. Die Studierenden erlernen weitere Vokabeln. Die Satzteile werden durch Einbindung modaler Erläuterungen zu Subjekt, Prädikat und Objekt in den Aussagesätzen erweitert.

Die Studierenden beschäftigen sich mit Themen, die relevant für die chinesische Kultur, ihre Sitten und Gebräuche sind.

#### Intended Learning Outcomes:

Nach der Teilnahme an der Modulveranstaltung sind die Studierenden in der Lage, ihre Meinungen in längerer, durchdachter und fein strukturierter Form zu formulieren. Sie können längere Sätze analysieren.

**Teaching and Learning Methods:**

Einzelarbeit, Partnerarbeit, Gruppenarbeit, Referate

Hausaufgaben zur Vor- und Nachbearbeitung sind freiwillig und fördern die Beherrschung der Zielsprache.

**Media:**

Lehrbuch, Übungsblätter, Audio-CD und multimedial gestütztes Lehr- und Lernmaterial

**Reading List:**

Lehrbuch wird in der Veranstaltung bekanntgegeben

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Chinesisch A2.2 (Seminar, 2 SWS)

Kralle J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0303: German as a Foreign Language A2.1 | Deutsch als Fremdsprache A2.1

Version of module description: Gültig ab summerterm 2022

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6                   | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht.

Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

gesicherte Kenntnisse der Stufe A1.2; Einstufungstest mit Ergebnis A2.1

#### Content:

In diesem Modul werden Grundkenntnisse in Deutsch als Fremdsprache unter Berücksichtigung interkultureller und landeskundlicher Aspekte vermittelt, die es den Studierenden ermöglichen, sich in einfachen, routinemäßigen Situationen zurechtzufinden, z.B. auf Reisen, beim Arzt, auf Wohnungssuche, im Kaufhaus, unter Kollegen, Freunden und Nachbarn.

Sie lernen/üben Vokabular/Ausdrucksmöglichkeiten zu Themen wie Studium und Ausbildung, Beruf, Wohnen, Medien und Reisen. Sie lernen/üben, einfach strukturierte Haupt- und Nebensätze (z.B. dass, weil, und, denn, etc.) zu benutzen, im Präteritum (Modalverben) und Perfekt zu

berichten, den Gebrauch des Komparativ und Superlativ und die Deklination des Adjektivs. Sie wiederholen und erweitern den Gebrauch der Präpositionen im Akkusativ und Dativ.

Es werden Möglichkeiten aufgezeigt, den Lernprozess eigenverantwortlich effektiver zu gestalten und damit die eigene Lernfähigkeit zu verbessern. Die Studierenden üben Teamkompetenz durch kooperatives Handeln in multinational gemischten Gruppen.

### **Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau A2 des GER

Nach Abschluss dieses Moduls sind die Studierenden in der Lage im Gespräch einfache Sätze und Redewendungen zu einem erweiterten Spektrum an vertrauten Themen zu verstehen und gebrauchen. Dabei handelt es sich um grundlegende Informationen zu alltäglichen oder studien- bzw. berufsrelevanten Themen unter Einbeziehung landeskundlicher Aspekte.

Sie können beispielsweise sich und andere Personen, persönliche Wohnsituation, Gesundheitszustand, Freizeitverhalten und berufliche Situation beschreiben.

Die Studierenden können längere Texte und Briefe zu vertrauten Themen verstehen, in denen gängige aber einfache alltags- oder berufsbezogene Sprache verwendet wird und in denen vorhersehbare Informationen zu finden sind. Sie können kurze, informative Texte oder Mitteilungen zu grundlegenden Situationen in Alltag und Studium zu verfassen.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner- und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online

### **Reading List:**

Lehrbuch: wird im Kurs bekannt gegeben

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Deutsch als Fremdsprache A2.1 (Seminar, 4 SWS)

Aßmann J, Bauer G, Comparato G, Geishauser C, Gemaljevic J, Keza I, Kovacs O, Kutschker T, Nierhoff-King B, Schlüter J, Semeraro G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ03031: Intensive Course German as a Foreign Language A2.1 | Blockkurs Deutsch als Fremdsprache A2.1

Version of module description: Gültig ab winterterm 2015/16

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>4                   | <b>Total Hours:</b><br>120 | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

1 final exam 90 min. (100%) - no learning aids permitted

The midterm exam is intended to monitor students' learning progress and reduce the amount of material covered in the final exam. Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing.

Verbal skills are evaluated using appropriate prompts from sample print dialogs.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Firm knowledge of level A1.2; placement test with the achievement A2.1

#### Content:

In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as traveling, at the doctor's office, searching for an apartment, in a department store, among colleagues, friends or neighbors.

Students learn and practice basic vocabulary and expressions on topics such as education, profession, health and traveling. Students learn and practice using simply structured main and subordinate clauses (that, because, and, than, etc.), employing the preterit (modal verbs) and perfect, as well as the comparative, the superlative and the declination of the adjective. They reinforce and expand the usage of the prepositions in the accusative and dative case.

Students learn strategies for successful verbal and written communication despite minimal language skills. Opportunities will be made available for effective, self-motivated, independent learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

**Intended Learning Outcomes:**

The module is based on level A2 of GER.

Upon completion of this module, students are able to understand and use simple sentences and expressions in conversations on a broad spectrum of familiar topics. These conversations are based on basic information concerning everyday life and subjects relevant to studying or working, including sociocultural aspects of German-speaking countries.

For example, students are able to describe themselves and other people, their living situation, state of health, leisure time activities and job situation.

Students are able to understand longer texts and letters about familiar topics that include foreseeable information and are written in simple language about everyday life or job related topics. Students are able to compose short, informative texts or notifications about basic situations in everyday life or situations related to studying.

**Teaching and Learning Methods:**

The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.

Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

**Media:**

Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

**Reading List:**

to be announced in the Class

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Blockkurs Deutsch als Fremdsprache A2.1 (Seminar, 4 SWS)

Gemaljevic J, Kretschmann A, Niebisch D, Semeraro G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0304: German as a Foreign Language A2.2 | Deutsch als Fremdsprache A2.2

Version of module description: Gültig ab summerterm 2022

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6                   | <b>Total Hours:</b><br>180 | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht. Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

gesicherte Kenntnisse der Stufe A2.1; Einstufungstest mit Ergebnis A2.2

#### Content:

In diesem Modul werden Grundkenntnisse in Deutsch als Fremdsprache unter Berücksichtigung interkultureller und landeskundlicher Aspekte vermittelt, die es den Studierenden ermöglichen, sich in einfachen, routinemäßigen Situationen zurechtzufinden, z.B. auf Reisen, beim Arzt, auf Wohnungssuche, im Kaufhaus, unter Kollegen, Freunden und Nachbarn.

Sie wiederholen und ergänzen grundlegendes Vokabular /Ausdrucksmöglichkeiten zu Themen wie Ausbildung, Beruf, Wohnen, Freizeit und Mobilität. Sie lernen/üben ein erweitertes Spektrum an Haupt- und Nebensätzen (z.B. indirekte Frage, temporaler Nebensatz) sowie den Konjunktiv II zu benutzen und sie wiederholen bzw. erweitern den Gebrauch der Präpositionen.



Es werden Möglichkeiten aufgezeigt, den Lernprozess eigenverantwortlich effektiver zu gestalten und damit die eigene Lernfähigkeit zu verbessern. Die Studierenden üben Teamkompetenz durch kooperatives Handeln in multinational gemischten Gruppen.

### **Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau A2 des GER.

Nach Abschluss dieses Moduls sind die Studierenden in der Lage im Gespräch einfache Sätze und Redewendungen zu einem erweiterten Spektrum an vertrauten Themen zu verstehen und zu gebrauchen. Dabei handelt es sich um grundlegende Informationen zu alltäglichen, oder studien- bzw. berufsrelevanten Themen unter Einbeziehung landeskundlicher Aspekte.

Sie können beispielsweise sich und andere Personen, die persönliche Wohnsituation, Gesundheitszustand, Freizeitverhalten und berufliche Situation im Präsens oder Perfekt beschreiben. Sie können Vorschläge machen und reagieren, Informationen austauschen und Ratschläge geben.

Die Studierenden können längere Texte und Briefe zu vertrauten Themen verstehen, in denen gängige aber einfache alltags- oder berufsbezogene Sprache verwendet wird und in denen vorhersehbare Informationen zu finden sind. Sie sind in der Lage kurze, informative Texte oder Mitteilungen zu grundlegenden Situationen in Alltag und Studium zu verfassen.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner- und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online

### **Reading List:**

Lehrbuch: wird im Kurs bekannt gegeben

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Deutsch als Fremdsprache A2.2 (Seminar, 4 SWS)

Aßmann J, Bauer G, Comparato G, Feistle C, Hagner V, Hanke C, Kostial M, Reulein C, Schimmack B, Selent D, Stiebeler H, Thiessen E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ03041: Intensive Course German as a Foreign Language A2.2 | Blockkurs Deutsch als Fremdsprache A2.2

Version of module description: Gültig ab winterterm 2015/16

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>4                   | <b>Total Hours:</b><br>120 | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

1 final exam 90 min. (100%) - no learning aids permitted

The midterm exam is intended to monitor students' learning progress and reduce the amount of material covered in the final exam. Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing.

Verbal skills are evaluated using appropriate prompts from sample print dialogs.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Firm knowledge of level A2.1; placement test with the achievement A2.2

#### Content:

In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as traveling, at the doctor's office, searching for an apartment, in a department store, among colleagues, friends or neighbors.

Students reinforce and augment basic vocabulary and expressions on topics such as education, profession, living and traveling. Students learn and practice classifying and using an extended spectrum of main and subordinate clauses (final clause, indirect questions, temporal subordinate clause, causal sentence). They also learn to employ the preterit (modals verbs) and perfect and will repeat and expand the usage of the prepositions and the declination of the adjective.

Students learn strategies for successful verbal and written communication despite minimal language skills. Opportunities will be made available for effective, self-motivated, independent learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

**Intended Learning Outcomes:**

The module is based on level A2 of GER.

Upon completion of this module, students are able to understand and use simple sentences and expressions in conversations on a broad spectrum of familiar topics. These conversations are based on basic information concerning everyday life and subjects relevant to studying or working, including sociocultural aspects of German-speaking countries.

For example, students are able to describe themselves and other people, their living situation, state of health, leisure time activities and job situation. Students are able to communicate in various situations, for example, when searching for an apartment, traveling or on holiday, and are able to report about their experiences in simple standard language.

Students are able to understand longer texts and letters about familiar topics that include foreseeable information and are written in simple language about everyday life or job related topics. Students are able to compose short, informative texts or notifications about basic situations in everyday life or situations related to studying.

**Teaching and Learning Methods:**

The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.

Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

**Media:**

Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

**Reading List:**

Textbook (to be announced in class)

**Responsible for Module:****Courses (Type of course, Weekly hours per semester), Instructor:**

Blockkurs Deutsch als Fremdsprache A2.2 (Seminar, 4 SWS)

Heiligensetzer M, Hoff L, Kretschmann A, Meuschel G, Niebisch D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **SZ0314: German as a Foreign Language B2+C1: Kommunikation at work: German for Internship and Job | Deutsch als Fremdsprache B2+C1: Kommunikation am Arbeitsplatz: Deutsch für Praktikum und Beruf**

Version of module description: Gültig ab summerterm 2022

|                                         |                            |                                  |                                  |
|-----------------------------------------|----------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>1                   | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht.

Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

gesicherte Deutschkenntnisse der Stufe B2.1, Einstufungsergebnis B2.2

gesicherte Deutschkenntnisse der Stufe C.1.1, Einstufungsergebnis C.1.1

#### **Content:**

Im Modul B2 werden Kenntnisse in Deutsch als Fremdsprache erarbeitet, die es Studierenden ermöglicht, im beruflichen Kontext aktiv und annähernd flüssig zu kommunizieren.

Die Studierenden verfassen E-Mails, simulieren Telefonate, Meetings und Small Talk sowie andere relevante Kommunikationssituationen.

Sie setzen Strategien und angemessenen Wortschatz ein, die effizientes Sprechen und Hören unterstützen.

Zusätzlich vertiefen sie ihre Kenntnisse zu Diskursmustern eines Meetings wie z.B. Vor- und Nachteile angeben, Vorschläge machen, Lösungen anbieten, widersprechen, vergleichen.

Im Modul C1 werden Kenntnisse in Deutsch als Fremdsprache erarbeitet, die es Studierenden ermöglicht, im beruflichen Kontext aktiv und flüssig zu kommunizieren.

Die Studierenden verfassen E-Mails, simulieren Telefonate, Meetings und Small Talk sowie andere relevante Kommunikationssituationen.

Sie setzen Strategien und differenzierten Wortschatz ein, die effizientes Sprechen und Hören unterstützen.

Zusätzlich vertiefen sie ihre Kenntnisse zu Diskursmustern eines Meetings wie z.B. Vor- und Nachteile angeben, Vorschläge machen, Lösungen anbieten, widersprechen, vergleichen.

### **Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau B2 des GER. Im Anschluss an die Teilnahme an die Modulveranstaltungen können die Studierenden auf formelle und informelle Kommunikationssituationen im Büroalltag mündlich spontan und zusammenhängend und schriftlich angemessen und in jeder Hinsicht verstehbar reagieren.

Sie sind in der Lage, anhand realitätsnaher Szenarien einem Meeting bzw. Telefonat in einer Firma zu folgen, sowie die wichtigen Punkte zu protokollieren und bei Bedarf nachzufragen.

Sie können annähernd flüssig argumentieren und auf die Argumente anderer eingehen, sofern sie in der Standardsprache vorgetragen werden.

Die Studierenden können formelle und informelle Redewendungen in E-Mails unterscheiden und je nach Situation ihren Stil anpassen.

Das Modul orientiert sich am Niveau C1 des GER. Im Anschluss an die Teilnahme an die Modulveranstaltungen können die Studierenden auf formelle und informelle Kommunikationssituationen im Büroalltag mündlich spontan und zusammenhängend und schriftlich kompetent reagieren.

Sie sind in der Lage, anhand realitätsnaher Szenarien einem Meeting bzw. Telefonat in einer Firma zu folgen, sowie die wichtigen Punkte strukturiert zu protokollieren und bei Bedarf gezielt nachzufragen.

Sie können flüssig argumentieren, auf die Argumente anderer eingehen und sie gegebenenfalls widerlegen.

Die Studierenden können formelle und informelle Redewendungen in E-Mails in differenzierter Weise einschätzen und je nach Situation ihren Stil anpassen.

### **Teaching and Learning Methods:**

Das Modul besteht aus einer Lehrveranstaltung, in der die angestrebten Lerninhalte mit gezielten Hör-, Lese- und Sprechübungen in Einzel-, Partner- und Gruppenarbeit kommunikativ und

handlungsorientiert erarbeitet werden. Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

**Media:**

multimedial gestütztes Lehr- und Lernmaterial, auch online

**Reading List:**

Lehrbuch: wird im Kurs bekannt gegeben

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Blockkurs Deutsch als Fremdsprache B2+C1 - Kommunikation am Arbeitsplatz - Deutsch für Praktikum und Beruf (Seminar, 2 SWS)

Reulein C, Thiessen E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0322: German as a Foreign Language A2.1 plus A2.2 | Deutsch als Fremdsprache A2.1 plus A2.2

Version of module description: Gültig ab summerterm 2022

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>8                   | <b>Total Hours:</b><br>270 | <b>Self-study Hours:</b><br>180  | <b>Contact Hours:</b><br>90                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht.

Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

gesicherte Kenntnisse der Stufe A1.2; Einstufungstest mit Ergebnis A2.1

#### Content:

In diesem Modul werden Grundkenntnisse in Deutsch als Fremdsprache unter Berücksichtigung interkultureller und landeskundlicher Aspekte vermittelt, die es den Studierenden ermöglichen, sich in einfachen, routinemäßigen Situationen zurechtzufinden, z.B. auf Reisen, beim Arzt, auf Wohnungssuche, im Kaufhaus, unter Kollegen, Freunden und Nachbarn.

Sie lernen/üben grundlegendes Vokabular/Ausdrucksmöglichkeiten zu Themen wie Ausbildung, Beruf, Gesundheit und Reisen. Sie lernen/üben ein erweitertes Spektrum an Haupt- und Nebensätzen zu klassifizieren und zu benutzen (Finalsatz, Infinitivsatz, indirekte Frage, temporaler Nebensatz, Kausalsatz), im Präteritum, Perfekt und Plusquamperfekt zu berichten, den Gebrauch

des Komparativ und des Superlativ, die Deklination des Adjektivs (im Nominativ, Akkusativ und Dativ) und Sie wiederholen und erweitern den Gebrauch der Präpositionen im Akkusativ und Dativ. Es werden Strategien vermittelt, die mündlich wie schriftlich eine Verständigung trotz noch geringer Sprachkenntnisse ermöglichen. Außerdem werden Möglichkeiten aufgezeigt, den Lernprozess eigenverantwortlich effektiver zu gestalten und damit die eigene Lernfähigkeit zu verbessern. Die Studierenden üben Teamkompetenz durch kooperatives Handeln in multinational gemischten Gruppen.

### **Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau A2 des GER. Nach Abschluss dieses Moduls sind die Studierenden in der Lage im Gespräch einfache Sätze und Redewendungen zu einem erweiterten Spektrum an vertrauten Themen zu verstehen und gebrauchen. Dabei handelt es sich um grundlegende Informationen zu alltäglichen, oder studien- bzw. berufsrelevanten Themen unter Einbeziehung landeskundlicher Aspekte.

Sie können beispielsweise sich und andere Personen, persönliche Wohnsituation, Gesundheitszustand, Freizeitverhalten und berufliche Situation beschreiben. Sie können sich bei der Wohnungssuche und in wesentlichen Situationen im Urlaub oder auf Reisen verständigen und von daraus resultierenden Erfahrungen und Erlebnissen in einfacher Standardsprache berichten. Die Studierenden können längere Texte und Briefe zu vertrauten Themen verstehen, in denen gängige aber einfache alltags- oder berufsbezogene Sprache verwendet wird und in denen vorhersehbare Informationen zu finden sind. Sie sind in der Lage kurze, informative Texte oder Mitteilungen zu grundlegenden Situationen in Alltag und Studium zu verfassen.

### **Teaching and Learning Methods:**

Die LV besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner- und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online

### **Reading List:**

Lehrbuch: wird im Kurs bekannt gegeben

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### SZ0331: German for Engineers C1 | Deutsch für Ingenieur/innen C1

Version of module description: Gültig ab summerterm 2022

|                                         |                            |                                  |                                             |
|-----------------------------------------|----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht. Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Deutschkenntnisse Niveau C1/gesicherte Deutschkenntnisse der Stufe B2.2

#### Content:

Das Modul orientiert sich am Niveau C1 des GER. In diesem Modul werden Kenntnisse in Deutsch als Fremdsprache erarbeitet, die es den Studierenden ermöglichen, in Studium und Beruf flüssig über ingenieurwissenschaftliche Themen des eigenen und eines fremden Fach- und Interessengebiets zu kommunizieren. Die Studierenden erarbeiten einen umfangreichen und differenzierten Wortschatz zu einem breiten Spektrum an technischen Themen. Sie verwenden Strategien, die effizientes Hören und Lesen im Fach unterstützen, vertiefen ihre Kenntnisse zu relevanten Strukturen wie z.B. zum Nominalstil und erweitern ihr Repertoire an fachsprachlichen Diskursmustern (z.B. Ursachen und Wirkungen beschreiben, definieren etc.). Im Seminar präsentieren sie einen komplexen Gegenstand ihres Faches und diskutieren aktuelle Themen mit ingenieurwissenschaftlichem Bezug.

**Intended Learning Outcomes:**

Im Anschluss an das Modul können die Studierenden relevanten Fachwortschatz kompetent verwenden und dabei auch komplexe Satzstrukturen produzieren. Sie können authentischen Lese- und Hörtexten wichtige Informationen in der für Studium und Beruf erforderlichen Schnelligkeit entnehmen. Sie verfügen über sprachliche Mittel, die erfolgreiche Kommunikation über ingenieurwissenschaftliche Zusammenhänge in interkulturellen sowie interdisziplinären Teams ermöglichen. Die Studierenden sind in der Lage, zu kontroversen Themen mit ingenieurwissenschaftlichem Bezug ausführlich und logisch nachvollziehbar Stellung zu beziehen.

**Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese- und Sprechübungen in Einzel-, Partner- und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Eine fachbezogene Präsentation zu Studieninhalten im Rahmen der Lehrveranstaltung ist obligatorisch. Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

**Media:**

multimedial gestütztes Lehr- und Lernmaterial, auch online

**Reading List:**

Lehrbuch: wird im Kurs bekannt gegeben

**Responsible for Module:****Courses (Type of course, Weekly hours per semester), Instructor:**

Deutsch für Ingenieur/innen C1 (Seminar, 2 SWS)

Hartkopf D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **SZ0332: German as a Foreign Language B2+C1 - Intercultural Communication Skills - "Working as an Engineer in Germany" | Deutsch als Fremdsprache B2+C1: Interkulturelle Kommunikation - Als IngenieurIn in Deutschland arbeiten**

Version of module description: Gültig ab summerterm 2022

|                                         |                            |                                  |                                  |
|-----------------------------------------|----------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>1                   | <b>Total Hours:</b><br>45  | <b>Self-study Hours:</b><br>30   | <b>Contact Hours:</b><br>15      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

1 schriftlicher Test 90 min. (100%), Hilfsmittel sind erlaubt.

In der schriftlichen Prüfung werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Dabei lösen die Kandidaten Aufgaben, die Faktenwissen zu Besonderheiten des deutschen Arbeitsmarktes und zu interkulturellen Modellen abfragen. Ferner wird die interkulturelle Reflexionskompetenz durch die schriftliche Analyse von Critical Incidents geprüft. 25% der Note besteht aus der Bewertung des sprachlichen Ausdrucks in der Fremdsprache Deutsch.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

gesicherte Deutschkenntnisse mindestens der Stufe B2.1

#### **Content:**

Das Modul orientiert sich am Niveau B2/C1 des GER. Im Seminar werden Kenntnisse in interkultureller Kommunikation erarbeitet, die es Studierenden in ingenieurwissenschaftlichen Fächern ermöglichen, interkulturell kompetent und zielführend in multinationalen Projektteams und im deutschen Arbeitskontext zu kommunizieren. Die Studierenden erarbeiten die Anwendung interkultureller Modelle zur Analyse komplexer, interkulturell anspruchsvoller Situationen im beruflichen Umfeld. Ferner erhalten Sie Faktenwissen über die Besonderheiten des deutschen Arbeitsmarktes, wie Sozialpartnerschaft, betriebliche Mitbestimmung, Inhalt und Aufbau eines Arbeitsvertrages, Unternehmensstrukturen, etc. Dazu erarbeiten sie sich den entsprechenden wirtschaftsdeutschen Fachwortschatz.

**Intended Learning Outcomes:**

Die Studierenden können erkennen, inwiefern und auf welche Weise die interkulturelle Komponente in der konkreten Zusammenarbeit in multikulturellen Teams eine Rolle spielt. Sie haben sich Tools zur Analyse und zielführenden Interpretation interkulturell komplexer Situationen erarbeitet und verfügt über die sprachlichen Mittel, diese kommunikativ umzusetzen, um eine gegenseitige Verständigung zu ermöglichen. Sie können nach Bedarf das eigene Wissen über abweichende kulturelle Werte und Standards durch gezieltes Nachfragen erweitern und die eigene Sichtweise darlegen. Sie können annähernd flüssig argumentieren und auf die Argumente anderer sowohl mündlich als auch schriftlich eingehen.

**Teaching and Learning Methods:**

Das Modul besteht aus einer Lehrveranstaltung, in der die angestrebten Lerninhalte anhand von Selbsterfahrungsübungen, Videomaterial, Critical Incidents und theoretischem Input in Einzel-, Partner- und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung und zur Vertiefung des eigenen Hintergrundwissens) festigen das Gelernte.

**Media:**

multimedial gestütztes Lehr- und Lernmaterial, auch online

**Reading List:****Responsible for Module:****Courses (Type of course, Weekly hours per semester), Instructor:**

Deutsch als Fremdsprache B2+C1 - Interkulturelle Kommunikation - "Als Ingenieur/in in Deutschland arbeiten" (Seminar, 2 SWS)

Moore B, Nierhoff-King B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0403: English - Academic Presentation Skills C1 - C2 | Englisch - Academic Presentation Skills C1 - C2

Version of module description: Gültig ab summerterm 2022

|                                         |                             |                                  |                                             |
|-----------------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Performance, testing the learning outcomes specified in the module description, is examined by a cumulative portfolio of competence and action-oriented tasks. These include four different graded extemporaneous speeches, three informative and one persuasive. Each graded speech contributes to 25% of the overall course grade. Aspects of proper delivery include proper oral citations, use of language, and implementation of rhetorical skills.

Students are evaluated on their ability to prepare and deliver speeches with the help of audio or visual aids and a handout. Depending on the course format, the presentations are delivered either live in person or via a video recording.

Where audio or video is recorded, the Basic Data Protection Regulation (DSGVO, Art. 12 -21) is observed.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Ability to begin work at the C2 level as evidenced by a placement test score of at least 75 percent.

#### Content:

This course allows students to practice and improve ability to carry out formal speaking tasks in English such as a class presentation, dissertation defense, department colloquium, conference talk or project proposals. All forms of presentations replicate academic speaking situations and include sections for question and answer or a debate format.

**Intended Learning Outcomes:**

This course helps students to gain practical experience in a range of both graded and non-graded presentation scenarios designed to build confidence and improve delivery in English. The acquired techniques and skill set can be successfully transferred to a number of academic and professional presentation scenarios. Students learn how to effectively write, practice and evaluate presentations in addition to giving and receiving constructive peer feedback.

**Teaching and Learning Methods:**

This course makes use of recording and/or classroom evaluation to help students develop their public speaking skill and uses a variety of training techniques such as extemporaneous speaking and PechaKucha to hone specific skills.

**Media:**

Text material, online platform, recordings. Videos and in-class modeled presentations and examples.

**Reading List:**

Handouts and selected extracts from published sources will be used in the course. Key literature will be advised by the teacher and/ or listed in the course description.

**Responsible for Module:****Courses (Type of course, Weekly hours per semester), Instructor:**

Englisch - Academic Presentation Skills C1 - C2 (Seminar, 2 SWS)

Field B, Jansen van Rensburg P

Blockkurs Englisch - Academic Presentation Skills C1 - C2 (Seminar, 2 SWS)

Ritter J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0406: English - Writing Academic Research Papers C2 | Englisch - Writing Academic Research Papers C2

Version of module description: Gültig ab summerterm 2022

|                                         |                           |                                  |                                             |
|-----------------------------------------|---------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b>          | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90 | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Performance, testing the learning outcomes specified in the module description, is examined by a cumulative portfolio of competence and action-oriented tasks. These include a 350-word abstract for an academic research paper (15%); a 15-minute oral “academic-conference-style” presentation of research and findings (35%); and complete an academic research paper of up to 5,000 words including references (APA/MLA style, 50%), in which they demonstrate an ability to critically engage in academic discourse, making use of rhetorical devices and conventions appropriate for their audience. The major assignment is based on multiple iterations of the academic research paper on which critical feedback has been given by the instructor.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Ability to begin work at at least the C1 level of the GER as evidenced by a score in the range of 60 – 80 percent on the placement test at [www.moodle.tum.de](http://www.moodle.tum.de). (Please check current announcements as the exact percentages may vary each semester.)

#### Content:

This is a process writing course during which students will study effective organization of written academic English incorporating discourse markers, topic sentences, and good paragraphing; study effective use of rhetorical structures appropriate to academic English: e.g. theme and rheme, nominalisation, use of passive, as well as register and style appropriate to target audience; and choose a topic commensurate with their interests/area of study and produce an abstract, a presentation and an academic research paper with the support of peers and tutor.

### **Intended Learning Outcomes:**

### **Teaching and Learning Methods:**

Students will:

- a) Research a topic and gather information pertinent to a self-chosen thesis/research question
- b) Prepare a presentation outlining their chosen research question or thesis which they will have to defend orally
- c) Work on their chosen topic with tutor support and regular tutorials

The tutor will:

- a) Give short input presentations with accompanying language based activities (pair work, group work) at the beginning of each sessions in the first half of the course
- b) Give regular tutorial support

### **Media:**

Powerpoint presentations (student and lecturer generated); Audio and visual recordings from a variety of sources; printed handouts.

### **Reading List:**

Handouts and selected extracts from published sources will be used in the course. Key literature will be advised by the teacher and/ or listed in the course description.

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Englisch - Writing Academic Research Papers C2 (Seminar, 2 SWS)

Hughes K, Sanchez D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### SZ0422-1: English - Jobline B2 | Englisch - Jobline B2

Version of module description: Gültig ab summerterm 2022

|                                         |                             |                                  |                                  |
|-----------------------------------------|-----------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>2                   | <b>Total Hours:</b><br>60   | <b>Self-study Hours:</b><br>30   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Performance, testing the learning outcomes specified in the module description, is examined by a cumulative portfolio of competence and action-oriented tasks including exercises and written assignments (75%), and a final written test (25%).

As the course may be offered in various formats (online or classroom) the form and conditions of the final exam (with or without aids) will vary. Where audio or video is recorded, we observe the Basic Data Protection Regulation (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

B2/C1 level according to the online placement test

#### Content:

This blended-learning course consists of sessions of face-to-face tuition in the classroom and self-study accessing the Jobline web-site ([www.jobline-lmu.de](http://www.jobline-lmu.de)) and doing the online activities. You will 'learn by doing'. You will gain practice in describing job advertisements and company requirements, writing CVs and cover-letters, practising for face-to-face and telephone job interviews.

#### Intended Learning Outcomes:

Upon completion of this module, students will have greater confidence in applying for jobs with international companies and have improved their fluency in spoken English in the job interview situation.

Corresponds to C1 of the CER.

**Teaching and Learning Methods:**

Pair- & groupwork, role-playing (interviewer-interviewee/job candidate)

**Media:**

Internet web-site: [www.jobline.lmu.de](http://www.jobline.lmu.de)

**Reading List:**

Internet web-site: [www.jobline.lmu.de](http://www.jobline.lmu.de)

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Englisch - Jobline B2 (Seminar, 2 SWS)

Hamzi-Schmidt E

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](#).

## Module Description

### SZ0442: English - The Science of Science Fiction C1 | Englisch - The Science of Science Fiction C1

Version of module description: Gültig ab summerterm 2022

|                                         |                             |                                  |                                  |
|-----------------------------------------|-----------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Performance, testing the learning outcomes specified in the module description, is examined by a cumulative portfolio of competence and action-oriented tasks including: written assignments in the form of forum entries (10%), a research/response essay (40%), as well as an oral presentation (including a handout and visual aids, 25%) and a final written examination with short essay questions (25%) in which students are expected to demonstrate a critical knowledge of common tropes of science fiction. In their forum entries, students are assessed on their ability to accurately summarize the content of textual and documentary evidence and analyze how it applies to principles discussed in class.

As the course may be offered in various formats (online or classroom) the form and conditions of the final exam (with or without aids) will vary. Where audio or video is recorded, we observe the Basic Data Protection Regulation (DSGVO, Art. 12 -21). Where audio or video is recorded, we observe the Basic Data Protection Regulation (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Ability to begin work at the C1 level of the GER based on the placement test at [www.moodle.tum.de](http://www.moodle.tum.de).

#### Content:

In this module communicative skills are practiced with a focus on topics of interest to students preparing for professions in science and technology branches which will be extrapolated from short works or excerpts taken from the work SF authors in the genre of science fiction such as Arthur C. Clarke, Ray Bradbury, Frank Herbert, Ursula K. LeGuin, Isaac Asimov, Octavia Butler, Robert

A. Heinlein, or William Gibson, in addition to video clips from classic science fiction films. Topics will be taken from such thematic areas as A.I. and Robots, Space and Time Travel, Weapons, Extraterrestrials, New Energies, The Quest for Longevity such as the so-called 'Singularity' and Parallel Worlds.

**Intended Learning Outcomes:**

After completion of this module students can understand a wide range of demanding, medium-length texts, and recognize implicit meaning; they can express themselves fluently and spontaneously without much obvious searching for expressions; they can use language flexibly and effectively for social, academic and professional purposes and they can produce clear, well-structured, detailed text on complex subjects, showing controlled use of organizational patterns, connectors and cohesive devices. In particular, students will be able to describe future events and speculative outcomes in a highly differentiated manner.

Corresponds to C1 of the CER.

**Teaching and Learning Methods:**

Communicative and skills oriented treatment of topics with use of group discussion, case studies, presentations, writing workshops, listening exercises, and pair work to encourage active use of language, and provide opportunities for ongoing feedback.

**Media:**

Use of online learning platform such as [www.moodle.tum.de](http://www.moodle.tum.de), presentations, short films and audio practice.

**Reading List:**

Handouts and selected extracts from published sources will be used in the course. Key literature will be advised by the teacher and/ or listed in the course description.

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](#).

## Module Description

### SZ0471: English - Intensive Thesis Writers' Workshop C2 | Englisch - Intensive Thesis Writers' Workshop C2

Version of module description: Gültig ab summerterm 2022

|                                         |                             |                                  |                                             |
|-----------------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Performance, testing the learning outcomes specified in the module description, is examined by a cumulative portfolio of competence and action-oriented tasks. Students' thesis-writing ability will be assessed based on their demonstration of clear improvements over the course of the workshop, showing that an effort has been made to implement the material discussed in class and the individual consultations with the instructor.

#### Repeat Examination:

#### (Recommended) Prerequisites:

For students currently writing theses or dissertations in English. Ability to begin work at the upper C1 or C2 level of the GER, as demonstrated by a score above 75% on the English placement test at [www.moodle.tum.de](http://www.moodle.tum.de). Basic understanding of grammatical terms (e.g., parts of speech, subject, verb, object, active, passive, nominalization).

#### Content:

This course is aimed at students currently writing theses or dissertations. It combines group seminars with individual consultations. All sessions go beyond mere questions of "correct" grammar and word choice and emphasize instead stylistic guidelines for compelling and clear English writing at a high academic level. Discussions have a slight emphasis on strategies for German speakers but are appropriate to students from any language background. The individual sessions are tailored to the needs of each student.

#### Intended Learning Outcomes:

After completion of this module, students will be able to express themselves with greater clarity and precision in written English. They will become more familiar with strategies for effective

academic writing in English specifically, while gaining a sense for potential contrasts with their own native languages. Students will develop techniques to implement compelling sentence constructions, create cohesion within and between sentences, and render paragraphs coherent through specific semantic and syntactic choices.

Corresponds to C2 of the CER.

**Teaching and Learning Methods:**

Seminars adopt a communicative and skills-oriented approach through group discussion, case studies, presentations, group work, etc. Individual sessions use students' texts as the primary learning materials.

**Media:**

Handouts, presentations, audio-visual material, students' own texts.

**Reading List:**

Handouts and selected extracts from published sources will be used in the course. Key literature will be advised by the teacher and/ or listed in the course description.

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Englisch - Intensive Thesis Writers' Workshop C2 (Workshop, 2 SWS)  
Jacobs R, Wellershausen N

Blockkurs Englisch Intensive Thesis Writers' Workshop C2 (Seminar, 2 SWS)  
Wellershausen N

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0502: French A1.2 | Französisch A1.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Lese- und Hörverstehen sowie zur freien Textproduktion und wird in Form von kompetenz- und handlungsorientierten kumulativen Prüfungsaufgaben abgehalten. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

- gesicherte Kenntnisse der Stufe A1.1
- Einstufungstest mit Ergebnis A1.2

#### Content:

In diesem Modul werden die Grundkenntnisse in französischer Lexik und Grammatik für einfache, mündliche und schriftliche Kommunikationssituationen im Alltag erweitert. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt. Der/Die Studierende lernt z.B., einfache Fragen zu Person und Familie zu stellen und zu beantworten, Verabredungen zu treffen, Reservierungen von Hotel zu tätigen, über Freizeit und Ferien zu berichten, vergangene Erlebnisse zu erzählen. Es werden u.a. folgende grammatische Themen behandelt: Passé Composé, Futur proche, Mengenangaben, Possessivbegleiter, direkte und indirekte Objektpronomen.

Es werden Strategien vermittelt, die eine Verständigung trotz noch geringer Sprachkenntnisse in alltäglichen Grundsituationen ermöglichen. Außerdem werden Möglichkeiten aufgezeigt,

den Lernprozess in der Fremdsprache effektiver zu gestalten und die eigene Lernfähigkeit zu verbessern.

**Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau „A1 – Elementare Sprachverwendung“ des GER. Der/ Die Studierende ist nach Abschluss dieses Moduls in der Lage, alltägliche Ausdrücke und sehr einfache Sätze zu verstehen und zu verwenden. Er/sie kann sich auf einfache Art verständigen, wenn die Gesprächspartnerinnen oder Gesprächspartner langsam und deutlich sprechen und bereit sind zu helfen. Er/sie kann einfache schriftliche Mitteilungen zur Person machen. Sowohl im mündlichen als auch im schriftlichen Sprachgebrauch ist der/die Studierende in der Lage, situationsadäquat, bzw. der A 1-Stufe entsprechend, Wortschatz und Grammatik korrekt anzuwenden.

**Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezieltem Hör-, Lese-, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Französisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor-und Nacharbeitung) festigen das Gelernte.

**Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial (Tafel, Folie, Übungsblätter, Bild, Film, etc.), auch online.

**Reading List:**

Lehrbuch (wird im Unterricht bekanntgegeben)

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Französisch A1.2 (Seminar, 2 SWS)

Bartanus J, Suek C, Worlitzer M

Blockkurs Französisch A1.2 (Seminar, 2 SWS)

Paul E, Suek C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### SZ0503: French A2.1 | Französisch A2.1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Lese- und Hörverstehen sowie zur freien Textproduktion und wird in Form von kompetenz- und handlungsorientierten kumulativen Prüfungsaufgaben abgehalten. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

- gesicherte Kenntnisse der Stufe A1
- Einstufungstest mit Ergebnis A2.1

#### Content:

In diesem Modul werden Grundkenntnisse in der Fremdsprache Französisch vermittelt, die es den Studierenden ermöglichen, sich in alltäglichen Grundsituationen zurechtzufinden, z.B. auf Reisen, beim Arzt, bei der Wohnungssuche, unter Kollegen, Freunden und Nachbarn. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt. Die grammatischen Strukturen werden weiter aufgebaut. Folgende grammatischen Themen werden behandelt, wie z.B. Verwendung von Passé Composé und Imparfait, Konditional, Relativpronomen, „en + y“ Pronomen, Komparativ und Superlativ.

Es werden Strategien vermittelt, die mündlich wie schriftlich eine Verständigung trotz noch geringer Sprachkenntnisse ermöglichen. Außerdem werden Möglichkeiten aufgezeigt, den Lernprozess effektiver zu gestalten und damit die eigene Lernfähigkeit zu verbessern. Ferner

werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Französisch effektiver zu gestalten und damit die eigene Lernfähigkeit zu verbessern.

**Intended Learning Outcomes:**

Das Modul orientiert sich am „A2 – Elementare Sprachverwendung“ des GER. Nach Abschluss dieses Moduls kann der/die Studierende einfache Sätze und Redewendungen zu einem erweiterten Spektrum an vertrauten Themen verstehen und gebrauchen. Er/Sie kann beispielsweise sich und andere Personen, persönliche Wohnsituation, Gesundheitszustand, Freizeitverhalten beschreiben. Er/Sie ist in der Lage, sich bei der Wohnungssuche und in wesentlichen Situationen im Urlaub oder auf (Geschäfts)Reisen zu verständigen und von daraus resultierenden Erfahrungen und Erlebnissen zu berichten. Er/Sie kann standardsprachliche Ausdrücke in vertrauten Kommunikationssituationen sowohl in mündlicher als auch in schriftlicher Form verstehen und verwenden und dabei Wortschatz und Grammatik korrekt anzuwenden.

**Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezieltem Hör-, Lese-, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Französisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

**Media:**

Lehrbuch, multimedial gestütztes Lehr- und Lernmaterial (Tafel, Folie, Übungsblätter, Bild, Film, etc.), auch online.

**Reading List:**

Lehrbuch (wird im Kurs bekanntgegeben)

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Französisch A2.1 (Seminar, 2 SWS)

Bruehl J, Petit-Lafortune J, Suek C, Worlitzer M

Blockkurs Französisch A2.1 (Seminar, 2 SWS)

Paul E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0504: French A2.2 | Französisch A2.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Lese- und Hörverstehen sowie zur freien Textproduktion und wird in Form von kompetenz- und handlungsorientierten kumulativen Prüfungsaufgaben abgehalten. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

- gesicherte Kenntnisse der Stufe A2.1
- Einstufungstest mit Ergebnis A2.2

#### Content:

In diesem Modul werden Grundkenntnisse in der Fremdsprache Französisch vermittelt, die es den Studierenden ermöglichen, sich in alltäglichen Grundsituationen zurechtzufinden. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt. Das Hör- und Leseverstehen sowie das Sprechen werden anhand verschiedener Hörübungen und Texten aus verschiedenen Bereichen des Alltagslebens und der Arbeitswelt trainiert. Die Wiederholung und Vertiefung der Grammatik orientiert sich an den kommunikativen Lernzielen. Es werden u.a. folgende grammatische Themen behandelt: Zukunft, Gerundium, indirekte Rede, Vergangenheitszeiten, Angleichung des Partizips, Subjonctif. Es werden Strategien vermittelt, die mündlich wie schriftlich eine Verständigung trotz noch geringer Sprachkenntnisse ermöglichen. Außerdem werden Möglichkeiten aufgezeigt, den Lernprozess effektiver zu gestalten und damit die eigene Lernfähigkeit zu verbessern.

**Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau „A2 – Elementare Sprachverwendung“ des GER. Nach Abschluss dieses Moduls kann der/die Studierende im Gespräch einfache Sätze und Redewendungen zu einem erweiterten Spektrum an vertrauten Themen verstehen und gebrauchen. Dabei handelt es sich um grundlegende Informationen zu alltäglichen, oder studien- bzw. berufsrelevanten Themen unter Einbeziehung landeskundlicher Aspekte. Der/die Studierende kann Texte und Briefe zu vertrauten Themen verstehen, in denen gängige aber einfache alltags- oder berufsbezogene Sprache verwendet wird und in denen vorhersehbare Informationen zu finden sind. Er/Sie ist in der Lage kurze, informative Texte oder Mitteilungen zu grundlegenden Situationen in Alltag und Studium zu verfassen.

**Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezieltem Hör-, Lese-, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Französisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

**Media:**

Lehrbuch, multimedial gestütztes Lehr- und Lernmaterial (Tafel, Folie, Übungsblätter, Bild, Film, etc.), auch online.

**Reading List:**

Lehrbuch (wird im Kurs bekanntgegeben)

**Responsible for Module:****Courses (Type of course, Weekly hours per semester), Instructor:**

Französisch A2.2 (Seminar, 2 SWS)

Bartanus J, Comte-Maillard C, Paul E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0505: French B1.1 | Französisch B1.1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Lese- und Hörverstehen sowie zur freien Textproduktion und wird in Form von kompetenz- und handlungsorientierten kumulativen Prüfungsaufgaben abgehalten. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

- gesicherte Kenntnisse der Stufe A2
- Einstufungstest mit Ergebnis B1.1

#### Content:

In diesem Modul werden Kenntnisse in der Fremdsprache Französisch erarbeitet, die es den Studierenden ermöglichen, (sich) in vertrauten Situationen, z.B. im Studium, Arbeit, Freizeit und Familie, und zu Themen von allgemeinem Interesse selbständig und sicher in der Zielsprache zu operieren/bewegen/verständigen, wenn Standardsprache verwendet wird. Dabei werden interkulturelle, landeskundliche und studienbezogene Aspekte berücksichtigt.

Die Studierenden vertiefen Ihre Kenntnisse anhand verschiedenster aktueller Themen des französischen Lebens. Sie erweitern Ihren Wortschatz sowie festigen und vertiefen die bisher erlernten grammatischen Schwerpunkte der französischen Sprache.

**Intended Learning Outcomes:**

Dieses Modul orientiert sich an Niveau "B 1- Selbständige Sprachverwendung" des GER. Der/die Studierende kann sich in den ihm/ihr vertrauten Situationen, denen man in Studium oder Beruf, Freizeit und auf Reisen im Sprachgebiet begegnet, sicher verständigen.

Er/sie kann wesentliche Inhalte in einfachen authentischen Texten aus alltäglichen Bereichen verstehen und sich an Gesprächen zu vertrauten Themen beteiligen. Er/sie ist in der Lage, persönliche Erfahrungen und Eindrücke schriftlich in eine längere Stellungnahme zum Ausdruck zu bringen.

Sowohl im mündlichen als auch im schriftlichen Sprachgebrauch ist der/die Studierende in der Lage, situationsadäquat, bzw. der B 1-Stufe entsprechend, Wortschatz und Grammatik korrekt anzuwenden.

**Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezieltem Hör-, Lese-, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Französisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

**Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial (Tafel, Folie, Übungsblätter, Bild, Film, etc.), auch online.

**Reading List:**

Lehrbuch (wird im Kurs bekanntgegeben)

**Responsible for Module:****Courses (Type of course, Weekly hours per semester), Instructor:**

Blockkurs Französisch B1.1 (Seminar, 2 SWS)

Bartanus J

Französisch B1.1 (Seminar, 2 SWS)

Bartanus J, Comte-Maillard C, Perconte-Duplain S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0507: French B2 - French for the profession | Französisch B2 - Le français pour la profession

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                  |
|-----------------------------------------|-------------------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Kumulative Tests: 50%

Präsentation: 30%

Hausarbeit: 20%

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Lese- und Hörverstehen sowie zur freien Textproduktion und wird in Form von kompetenz- und handlungsorientierten kumulativen Prüfungsaufgaben abgehalten. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21). Zu der Prüfungsleistung gehören eine kurze Präsentation auf Französisch zu einem kulturbezogenen, gesellschaftlichen oder wissenschaftlichen Thema im Zusammenhang mit der Arbeitswelt. Diese Präsentation ist eigenverantwortlich mündlich wie schriftlich zu gestalten bzw. vorzutragen. Anschließend sollen auch Fragen zur eigenen Präsentation beantwortet werden können. Die Hausarbeit (Form, Umfang und Thema) wird am Anfang des Semesters genau mit den Studierenden abgesprochen.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- gesicherte Kenntnisse der Stufe B1
- Einstufungstest mit Ergebnis B2

#### Content:

In diesem Modul werden Kenntnisse in der Fremdsprache Französisch aufgebaut und vertieft, die es den Studierenden ermöglichen, aktiv und mit einem gewissen Grad an Flüssigkeit über Themen



von allgemeinen oder beruflichen Interesse mit einem Muttersprachler zu diskutieren und eine Argumentation gut verständlich ausführen.

Das Modul gibt einerseits eine Einleitung in das Französisch der Arbeitswelt und bereitet andererseits die Studierenden auf einen Studienaufenthalt oder ein Praktikum im frankophonen Sprachraum. Besonderes Augenmerk wird auf die Entwicklung kommunikativer Fähigkeiten und interkultureller Kompetenz gelegt. Zur Festigung der mündlichen und schriftlichen Fertigkeit werden Schwerpunkte der Grammatik wiederholt und vertieft. In diesem Modul bildet das Thema „Bewerben in Frankreich“ eine zentrale Rolle.

### **Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau „B2- Selbständige Sprachverwendung“ des GER. Der/die Studierende ist in der Lage, durch situationsrelevantes interkulturelles Wissen über Universitäten und Berufswelt im französischen Sprachraum angemessen zu kommunizieren und einen Studien-, Projekt- oder Forschungsaufenthalt, ein Praktikum oder Weiterbildungsmaßnahmen im französischen Sprachraum zu absolvieren.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezieltem Hör-, Lese-, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Französisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial (Tafel, Folie, Übungsblätter, Bild, Film, etc.), auch online.

### **Reading List:**

wird in der Lehrveranstaltung bekannt gegeben

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Französisch B2 Le français pour la profession (Seminar, 2 SWS)

Gaulon A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0511: French B2/C1 - France currently | Französisch B2/C1 - La France actuelle

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                  |
|-----------------------------------------|-------------------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Kumulative Tests: 80%

Präsentation: 20%

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Lese- und Hörverstehen sowie zur freien Textproduktion und wird in Form von kompetenz- und handlungsorientierten kumulativen Prüfungsaufgaben abgehalten. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21). Zu der Prüfungsleistung gehört auch eine kurze Präsentation auf Französisch zu einem kulturbezogenen, gesellschaftlichen oder wissenschaftlichen Thema im Zusammenhang mit Frankreich oder dem französischen Sprachraum. Diese Präsentation ist eigenverantwortlich mündlich wie schriftlich zu gestalten bzw. vorzutragen. Anschließend sollen auch Fragen zur eigenen Präsentation beantwortet werden können.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- gesicherte Kenntnisse der Stufe B1
- Einstufungstest mit Ergebnis B2

#### Content:

In diesem Modul werden Kenntnisse in der Fremdsprache Französisch aufgebaut und vertieft, die es den Studierenden ermöglichen, aktiv und mit einem gewissen Grad an Flüssigkeit über Themen von allgemeinem Interesse oder von vertrautem Fachgebiet mit einem Muttersprachler zu

diskutieren und eine Argumentation gut verständlich ausführen. Zur Festigung der mündlichen und schriftlichen Fertigkeit werden Schwerpunkte der Grammatik wiederholt und vertieft.

Dieses Modul bietet einen Querschnitt durch die gegenwärtige Kultur Frankreichs, indem gesellschaftliche Tendenzen anhand von Zeitungsartikeln, Radio- und Fernsehausschnitten, diskutiert werden. Auf individuelle Themenvorschläge wird gerne eingegangen.

### **Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau „B2-C1“ des GER, je nach Wissenstand der Studierenden. Nach Abschluss des Moduls kann der/die Studierende auf sehr hohem Niveau über aktuellen Themen detaillierte, zusammenhängende Texte berichten, Informationen zusammenfassen, seine/ihre Erfahrungen und Eindrücke wiedergeben, seinen/ihren Standpunkt vertreten. Er/sie kann Inhalte von Lektüren, Gespräche oder Sendungen wiedergeben und seine/ihre Meinung vertreten. Er/sie kann sich spontan und fließend ausdrücken, ohne öfter deutlich erkennbar nach Worten suchen zu müssen. Er/sie ist in der Lage, zu vielen Themen aus seinen/ihren Interessen- oder Fachgebieten klar und strukturiert in mündlicher und schriftlicher Form zu kommunizieren.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezieltem Hör-, Lese-, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Französisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial (Tafel, Folie, Übungsblätter, Bild, Film, etc.), auch online.

### **Reading List:**

internes Material

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Französisch B2/C1 La France actuelle (Seminar, 2 SWS)

Bruehl J, Gommeringer-Depraetere S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0515: French C1 - Upper Conversation Course | Französisch C1 - Cours de conversation supérieure

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                  |
|-----------------------------------------|-------------------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Kumulative Tests: 60%

Präsentation: 20%

Hausarbeit: 20%

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Lese- und Hörverstehen sowie zur freien Textproduktion und wird in Form von kompetenz- und handlungsorientierten kumulativen Prüfungsaufgaben abgehalten. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21). Zu der Prüfungsleistung gehört auch eine kurze Präsentation auf Französisch zu einem kulturbezogenen, gesellschaftlichen oder wissenschaftlichen Thema im Zusammenhang mit Frankreich oder dem französischen Sprachraum. Diese Präsentation ist eigenverantwortlich mündlich wie schriftlich zu gestalten bzw. vorzutragen. Anschließend sollen auch Fragen zur eigenen Präsentation beantwortet werden können. Die Hausarbeit (Form, Umfang und Thema) wird am Anfang des Semesters genau mit den Studierenden abgesprochen.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- gesicherte Kenntnisse der Stufe B2
- Einstufungstest mit Ergebnis C1

**Content:**

In diesem Modul werden Kenntnisse in der Fremdsprache Französisch erarbeitet, die es den Studierenden ermöglichen, mündlich wie schriftlich in Themenbereichen aus Alltag, Beruf und Kultur situationsadäquat zu handeln (agieren und reagieren). Anhand von Literatur, aktuellen Presseartikeln, Radio- und Fernsehausschnitten werden soziokulturelle Zusammenhänge aktueller Themen reflektiert. Auf individuelle Themenvorschläge wird gerne eingegangen. Es werden Kenntnisse in den benannten Bereichen vertieft und Aspekte der Grammatik wiederholt und ergänzt.

**Intended Learning Outcomes:**

Dieses Modul orientiert sich an Niveau "C1-Kompetente Sprachverwendung" des GER. Nach der Teilnahme an der Lehrveranstaltung kann der/die Studierende auf sehr hohem Niveau in unterschiedlichsten Situationen mündlich und schriftlich kommunizieren. Er/Sie ist in der Lage, die Fremdsprache mündlich und schriftlich sowohl im Auslandsstudium als auch im Beruf wirksam und flexibel zu gebrauchen. Er/Sie kann ein breites Spektrum anspruchsvoller, längerer Texte verstehen und auch implizite Bedeutungen erfassen. Er/Sie kann sich spontan und fließend ausdrücken, ohne öfter deutlich erkennbar nach Worten suchen zu müssen. Er/Sie kann sich klar, strukturiert und ausführlich zu komplexen Sachverhalten äußern und dabei verschiedene Mittel zur Textverknüpfung angemessen verwenden.

**Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezieltem Hör-, Lese-, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Französisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

**Media:**

Presseartikel, multimedial gestütztes Lehr- und Lernmaterial (Tafel, Folie, Übungsblätter, Bild, Film, etc.), auch online.

**Reading List:**

wird in der Lehrveranstaltung bekannt gegeben

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Französisch C1 - Cours de conversation supérieure (Seminar, 2 SWS)

Perconte-Duplain S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0606: Italian A2.1 | Italienisch A2.1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Lese- und Hörverstehen sowie zur freien Textproduktion. Hilfsmittel erlaubt. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse des Moduls A1.2 (bestandene Klausur) oder Einstufungstest mit Ergebnis A2.1.

#### Content:

In diesem Modul werden Grundkenntnisse in der Fremdsprache Italienisch aufgebaut, die den Studierenden –trotz noch geringer Sprachkenntnisse- erlauben, sich in Alltagssituationen wie z. B. beim Einkaufen oder auf Reisen, in der Konversation und dem Austausch unter Kollegen, Freunden und Nachbarn zurechtzufinden. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt.

Der/die Studierende lernt u.a. über vergangene Ereignisse mündlich und schriftlich zu berichten; Ratschläge und Anweisungen zu geben; kurze formelle oder informelle E-Mails zu schreiben, sich telefonisch über etwas zu erkundigen. Wortschatz und Grammatik werden weiter aufgebaut. U.a. werden grammatische Themen, wie z.B. Passato prossimo mit unregelmäßigen Partizipien; direkte Objektpronomen und „ne“ in Verbindung mit dem Passato prossimo; Bildung und Gebrauch des Adverbs; Imperativ und Stellung der Pronomen. Ferner werden Möglichkeiten und Strategien aufgezeigt, die den Lernprozess in der Fremdsprache Italienisch effektiver gestalten sollen.

**Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau A2 – „Elementare Sprachverwendung“ des Gemeinsamen Europäischen Referenzrahmens für Sprachen.

Nach Abschluss des Moduls ist der/die Studierende in der Lage, beim Hören bzw. Lesen die wichtigsten Informationen zu bekannten Themen und in routinemäßigen Situationen zu verstehen. Mündlich und schriftlich kann er/sie u.a. Ereignisse und Erlebnisse in der Vergangenheitsform in sehr einfacher Form schildern; er kann kurze formelle und informelle E-Mails verfassen sowie Informationen am Telefon erfragen; er/sie kann Ratschläge und Anweisungen geben.

**Teaching and Learning Methods:**

Kommunikatives und handlungsorientiertes Erarbeiten der Inhalte; gezielte Hör-, Lese-, Schreib- und Sprechübungen; Einzel-, Partner- und Gruppenarbeit; Förderung kooperativen Lernens; Kontrolliertes Revidieren einzelner Aspekte der Grammatik mit vorgegebenen (online-) Materialien; Referieren und Präsentieren; moderierte Diskussionen.

Freiwillige Hausaufgaben zur Vor- und Nachbereitung festigen das Gelernte.

**Media:**

Lehrwerk; multimedial gestütztes Lehr- und Lernmaterial

**Reading List:**

Lehrwerk (wird im Unterricht bekannt gegeben)

**Responsible for Module:****Courses (Type of course, Weekly hours per semester), Instructor:**

Italienisch A2.1 (Seminar, 2 SWS)

Aquaro M, Mainardi D, Villadei M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### SZ0607: Italian A2.1 + A2.2 - Intensive | Italienisch A2.1 + A2.2 - Intensiv

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                  |
|-----------------------------------------|-------------------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>6                   | <b>Total Hours:</b><br>180          | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Lese- und Hörverstehen sowie zur freien Textproduktion. Hilfsmittel erlaubt. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse des Moduls A1.2 (bestandene Klausur) oder Einstufungstest mit Ergebnis A2.1.

#### Content:

Abschlussmodul des A-Niveaus des Gemeinsamen Europäischen Referenzrahmens für Sprachen (Grundstufe)

In diesem Modul werden Grundkenntnisse in der Fremdsprache Italienisch aufgebaut, die es den Studierenden – trotz noch geringer Sprachkenntnisse - ermöglichen, sich in Alltagssituationen wie z.B. beim Einkaufen oder bei der Wohnungssuche zurechtzufinden. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt.

Der/die Studierende lernt u.a. von Geschehnissen, Situationen und Gewohnheiten in der Vergangenheitsform zu erzählen; Personen physisch und charakterlich zu beschreiben; über die Familie zu sprechen; eine höfliche Aufforderung, einen Wunsch, eine Vermutung auszudrücken; Ratschläge bzw. Anweisungen zu geben; eine Entscheidung zu begründen und die eigene Meinung zu äußern.

Grammatische Themen wie z.B. Passato prossimo, Imperfetto, Adverbien, Imperativ, Konditional Präsens, Relativpronomen, Adverbien werden behandelt. Grundlegendes Wortschatz zu vertrauten Themen wie z.B. Einkaufen, Familie, Freunde, Wohnen, Kleidung wird gelernt und geübt.

Es werden Strategien vermittelt, die mündlich wie schriftlich eine Verständigung trotz geringer Sprachkenntnisse erlauben. Außerdem werden Möglichkeiten aufgezeigt, wie man den Lernprozess in der Fremdsprache Italienisch eigenverantwortlich und effektiv gestalten kann.

### **Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau A2 „Elementare Sprachverwendung“ des Gemeinsamen Europäischen Referenzrahmens für Sprachen.

Nach Abschluss des Moduls ist der/die Studierende in der Lage, beim Hören bzw. Lesen die wichtigsten Informationen zu bekannten und allgemeinen Themen zu verstehen. Mündlich und schriftlich kann er/sie u.a. auf elementare Weise von Geschehnissen, Situationen und Gewohnheiten in der Vergangenheitsform erzählen; Personen beschreiben (Charakter- und Körpereigenschaften); höfliche Aufforderungen, Wünsche, Vermutungen ausdrücken; Ratschläge bzw. Anweisungen geben; Entscheidungen kurz begründen; die eigene Meinung äußern. Er/sie kann grundlegendes Vokabular zu Themen wie Familie und Verwandtschaft, Kleidung, Wohnen, Ernährung verstehen und verwenden.

### **Teaching and Learning Methods:**

Kommunikatives und handlungsorientiertes Erarbeiten der Inhalte; gezielte Hör-, Lese-, Schreib- und Sprechübungen; Einzel-, Partner- und Gruppenarbeit; Förderung kooperativen Lernens; Kontrolliertes Revidieren einzelner Aspekte der Grammatik mit vorgegebenen (online-) Materialien; Referieren und Präsentieren; moderierte Diskussionen.

Freiwillige Hausaufgaben zur Vor- und Nachbereitung festigen das Gelernte.

### **Media:**

Lehrwerk; multimedial gestütztes Lehr- und Lernmaterial.

### **Reading List:**

Lehrwerk (wird im Unterricht bekannt gegeben)

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Italienisch A2.1+A2.2 - Intensiv (Seminar, 4 SWS)

Soares da Silva D, Togni M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0608: Italian A2.2 | Italienisch A2.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Lese- und Hörverstehen sowie zur freien Textproduktion. Hilfsmittel erlaubt. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse des Moduls A2.1 (bestandene Klausur) oder Einstufungstest mit Ergebnis A2.2.

#### Content:

Abschlussmodul des A-Niveaus des Gemeinsamen Europäischen Referenzrahmens für Sprachen (Grundstufe)

In diesem Modul werden Grundkenntnisse in der Fremdsprache Italienisch vermittelt, die es den Studierenden ermöglichen, sich in alltäglichen Grundsituationen zurechtzufinden. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt.

Der/die Studierende lernt und übt u.a. eine höfliche Aufforderung, einen Wunsch, eine Vermutung auszudrücken; eine Entscheidung kurz zu begründen; die eigene Meinung in elementarer Form zu äußern. Gewohnheiten und Zustände in der Vergangenheit zu schildern. Grammatische Themen wie u.a. Konditional Präsens; Imperfetto; Relativpronomen werden gelernt und geübt. Grundlegendes Vokabular zu vertrauten Themen wie z. B. Familie, Freunde, Wohnen, Internet und soziale Netzwerke wird gelernt, geübt und gefestigt.

Es werden Strategien vermittelt, die mündlich wie schriftlich eine Verständigung trotz geringer Sprachkenntnisse erlauben. Außerdem werden Möglichkeiten aufgezeigt, wie man den Lernprozess in der Fremdsprache Italienisch eigenverantwortlich und effektiv gestalten kann.

**Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau A2 „Elementare Sprachverwendung“ des Gemeinsamen Europäischen Referenzrahmens für Sprachen.

Nach Abschluss des Moduls kann der/die Studierende im Gespräch elementare Sätze und Ausdrücke zu einem erweiterten Spektrum an vertrauten Themen wie z.B. Wohnen, Familien, Freunden verstehen und gebrauchen. Er/sie kann längere Texte zu bekannten und allgemeinen Themen verstehen, in denen gängige bzw. einfache, alltagsbezogene Sprache verwendet wird und in denen vorhersehbare Informationen zu finden sind. Er/sie ist zudem in der Lage, kurze, informative Texte schriftlich zu verfassen sowie höfliche Aufforderungen, Wünsche, Vermutungen auszudrücken; Entscheidungen kurz zu begründen; die eigene Meinung in einfacher Form zu äußern.

**Teaching and Learning Methods:**

Kommunikatives und handlungsorientiertes Erarbeiten der Inhalte; gezielte Hör-, Lese-, Schreib- und Sprechübungen; Einzel-, Partner- und Gruppenarbeit; Förderung kooperativen Lernens; Kontrolliertes Revidieren einzelner Aspekte der Grammatik mit vorgegebenen (online-) Materialien; Referieren und Präsentieren; moderierte Diskussionen.

Freiwillige Hausaufgaben zur Vor- und Nachbereitung festigen das Gelernte.

**Media:**

Lehrwerk; multimedial gestütztes Lehr- und Lernmaterial.

**Reading List:**

Lehrwerk (wird im Unterricht bekannt gegeben)

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Italienisch A2.2 (Seminar, 2 SWS)

Alfieri L, Aquaro M, Bonvicin A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0609: Italian B1.1 | Italienisch B1.1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Lese- und Hörverstehen sowie zur freien Textproduktion. Hilfsmittel erlaubt. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse der Stufe A2.2 (bestandene Klausur) oder Einstufungstest mit Ergebnis B1.1

#### Content:

In diesem Modul werden Kenntnisse in der Fremdsprache Italienisch erarbeitet, die es den Studierenden ermöglichen, sich in vertrauten Situationen, z.B. in Studium, Arbeit, Freizeit und Familie, und zu Themen von allgemeinem Interesse wie Aktualität, Gesellschaft, Sport sicherer in der Zielsprache zu verständigen, wenn Standardsprache verwendet wird. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt.

Die Studierenden festigen und vertiefen die bisher erlernten Sprachstrukturen des A-Niveaus und lernen/üben u.a. längere Berichte über vergangene Erfahrungen in mündlicher und schriftlicher Form zu verfassen; längere authentische Texte zusammenzufassen; Meinungen präziser zu äußern und zu widersprechen; für und gegen etwas zu argumentieren. Dazu werden entsprechende, hierfür notwendige grammatische Themen bzw. Wortschatz behandelt, gefestigt und vertieft. Außerdem werden Möglichkeiten aufgezeigt, wie man den Lernprozess in der Fremdsprache Italienisch eigenverantwortlich und effektiv gestalten kann.

**Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau B1 „Selbständige Sprachverwendung“ des Gemeinsamen Europäischen Referenzrahmens für Sprachen.

Nach Abschluss des Moduls sind die Studierenden in der Lage, sich in den meisten Situationen, denen man in Studium oder in der Freizeit im Sprachgebiet begegnet, sicherer zu verständigen und zu alltäglichen Themen eine persönliche Meinung zu äußern und zu widersprechen bzw. für und gegen etwas zu argumentieren.

Die Studierenden können wesentliche Inhalte in einfachen, authentischen Texten aus alltäglichen Bereichen verstehen und in einfacher Form wiedergeben und sich spontan an Gesprächen zu vertrauten Themen beteiligen. Sie können längere Texte zu Alltagsthemen oder zu eigenen Erfahrungen verfassen.

**Teaching and Learning Methods:**

Kommunikatives und handlungsorientiertes Erarbeiten der Inhalte; gezielte Hör-, Lese-, Schreib- und Sprechübungen; Einzel-, Partner- und Gruppenarbeit; Förderung kooperativen Lernens; Kontrolliertes Revidieren einzelner Aspekte der Grammatik mit vorgegebenen (online-) Materialien; Referieren und Präsentieren; moderierte Diskussionen.

Freiwillige Hausaufgaben zur Vor- und Nachbereitung festigen das Gelernte.

**Media:**

multimedial gestütztes Lehr- und Lernmaterial, auch online.

**Reading List:**

Lehrbuch (wird im Unterricht bekannt gegeben)

**Responsible for Module:****Courses (Type of course, Weekly hours per semester), Instructor:**

Italienisch B1.1 (Seminar, 2 SWS)

Schmidt C, Togni M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0719: Japanese A2.1 + A2.2 | Japanisch A2.1 + A2.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                  |
|-----------------------------------------|-------------------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>6                   | <b>Total Hours:</b><br>180          | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhaltet Aufgaben zur Anwendung von Schriftzeichen, Wortschatz und Grammatik, zu Lese- und Hörverstehen sowie zur freien Textproduktion und wird in Form von kompetenz- und handlungsorientierten (Portfolio-)Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Erfolgreiche Teilnahme an der Stufe A 1.4 oder vergleichbare Kenntnisse

#### Content:

In dieser LV werden die Grundkenntnisse des Japanischen erweitert, die es den Studierenden ermöglichen, sich in alltäglichen Situationen mit Basissprachkenntnissen zurechtzufinden. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt. Das Erlernen der Schriftzeichen (Kanji) ist ebenfalls grundlegend. Um dieses Ziel zu erreichen, wird Kommunikation im Kontext folgender Situationen eingeübt: einfache Meinungen äußern; Abläufe/Zustand erklären; mit Freunden/der Familie im „einfachen Stil“ (nicht im „höflichen Stil“) sprechen etc. Dazu werden u.a. folgende Themen der Grammatik behandelt: direkte u. indirekte Rede, Konditionalsätze, Potenzialverben und Verbenpaare (transitiv/intransitiv). Die Studierenden lernen, in einfach strukturierten Haupt- und Nebensätzen Alltägliches zu berichten/erfragen.

**Intended Learning Outcomes:**

Nach Abschluss dieses Moduls kann der/die Studierende im Gespräch einfache Sätze und Redewendungen zu einem erweiterten Spektrum an vertrauten Themen verstehen und gebrauchen. Dabei handelt es sich um grundlegende Informationen zu alltäglichen Themen unter Einbeziehung landeskundlicher Aspekte. Der/die Studierende ist in der Lage, Pläne, Wünsche und Hoffnungen zu äußern, Einladungen auszusprechen, anzunehmen oder abzulehnen. Außerdem kann er/sie neben den japanischen Silbenschriften Hiragana und Katakana ca. 180 für den Alltag relevante Kanji (chinesische Schriftzeichen) verstehen und verwenden.

**Teaching and Learning Methods:**

Kommunikatives und handlungsorientiertes Erarbeiten der Inhalte; Gezielte Hör-, Lese-, Schreib- und Sprechübungen; Einzel-, Partner- und Gruppenarbeit; Förderung kooperativen Lernens. Freiwillige Hausaufgaben (zur Vor- und Nachbearbeitung) festigen das Gelernte.

**Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial

**Reading List:**

Lehrbuch (wird in der Lehrveranstaltung bekanntgegeben)

Vom Kursleiter selbst angefertigte/zusammengestellte Arbeitsblätter, (online-) Materialien.

**Responsible for Module:****Courses (Type of course, Weekly hours per semester), Instructor:**

Japanisch A2.1 + A2.2 (Seminar, 4 SWS)

Abe M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### SZ0806: Portuguese A2.1 | Portugiesisch A2.1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht. Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bestandene Abschlussklausur oder gesicherte Kenntnisse der Niveau A1.

#### Content:

In diesem Modul werden Grundkenntnisse in Portugiesisch unter Berücksichtigung plurikultureller, plurilingualer und landeskundlicher Aspekte vermittelt, die es den Studierenden ermöglichen, sich einfachen, routinemäßigen Situationen zurechtzufinden, z.B. auf Reisen, beim Arzt, auf Wohnungssuche, im Kaufhaus, unter Kollegen, Freunden und Nachbarn.

Die Studierenden lernen/üben u.a.: Vergleiche anzustellen, über Erfahrungen zu sprechen und sie zu bewerten, über Alltagsaktivitäten zu berichten und diese zu planen, über vergangene Ereignisse zu berichten und Zustände und Probleme zu beschreiben und vergleichen. Dazu werden entsprechende, hierfür notwendige grammatische Themen bzw. Wortschatz behandelt. Es werden Strategien vermittelt, die mündlich wie schriftlich eine Verständigung trotz noch geringer Sprachkenntnisse ermöglichen. Außerdem werden Möglichkeiten aufgezeigt, den Lernprozess

eigenverantwortlich effektiver zu gestalten und damit die eigene Lernfähigkeit zu verbessern. Die Studierenden üben soziale und interkulturelle kommunikative Kompetenz durch kooperatives Handeln und Mediation (auch online).

Im Unterricht wird zugleich auf die grammatikalischen und phonetischen Unterschiede zwischen Sprachvarietäten des Portugiesisch eingegangen.

### **Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau A2 des GER.

Nach Abschluss des Moduls sind die Studierenden in der Lage, im Gespräch einfache Sätze und Redewendungen zu einem erweiterten Spektrum an vertrauten Themen zu verstehen und gebrauchen. Dabei handelt es sich um grundlegende Informationen zu alltäglichen oder studien- bzw. berufsrelevanten Themen unter Einbeziehung landeskundlicher Aspekte.

Sie können beispielsweise sich und andere Personen, persönliche Wohnsituation, Gesundheitszustand, Freizeitverhalten und berufliche Situation beschreiben. Sie können die vergangenen Ereignisse in Perfekt verstehen und schriftlich und mündlich ausdrücken.

Die Studierenden können längere Texte und Briefe zu vertrauten Themen verstehen, in denen gängige aber einfache alltags- oder berufsbezogene Sprache verwendet wird und in denen vorhersehbare Informationen zu finden sind. Sie können kurze, informative Texte oder Mitteilungen zu grundlegenden Situationen in Alltag und Studium verfassen.

Die Studierenden können erkennen, wenn Schwierigkeiten auftreten und in einfacher Sprache andeuten, welcher Art das Problem offenkundig ist. Sie können die Hauptpunkte kurzer, einfacher Gespräche oder Texte zu alltäglichen Themen von unmittelbarem Interesse übermitteln, sofern diese klar in einfacher Sprache ausgedrückt sind.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner- und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Dadurch wird die Interaktion und Mediation mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln, unter Berücksichtigung der sozialen und interkulturellen Kompetenz. Lernautonomie und Medienkompetenz werden angestrebt.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online.

### **Reading List:**

Lehrbuch (wird in der LV bekannt gegeben)

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Blockkurs Portugiesisch A2.1 (Seminar, 2 SWS)

de Sena Lang J

Portugiesisch A2.1 (Seminar, 2 SWS)

Paiva Pissarra R, Viegas Cunha R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **SZ08061: Intensive Course Portuguese A2.1 | Blockkurs Portugiesisch A2.1**

## Module Description

### SZ0807: Portuguese A2.2 | Portugiesisch A2.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht. Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bestandene Abschlussklausur oder gesicherte Kenntnisse der Niveau A2.1

#### Content:

In diesem Modul werden Grundkenntnisse in Fremdsprache Portugiesisch unter Berücksichtigung plurikultureller, plurilingueller und landeskundlicher Aspekte, die es den Studierenden ermöglichen, sich in einfachen, routinemäßigen Situationen zurechtzufinden, z. B. Studium und Ausbildung, Beruf, Wohnen, Medien und Reisen.

Die Studierenden lernen/üben in komplexerer Struktur u.a. wie man Meinungen äußert und darauf reagiert; wie man über die Ursachen und Folgen von etwas spricht; wie man Anweisungen gibt; wie man Situationen und Ereignisse in der Vergangenheit schildert; wie man Geschichten erzählt. Wie man einfache Diskussionen führen kann, eine Auswahl treffen und begründen. Dazu werden entsprechende, hierfür notwendige grammatische Themen bzw. Wortschatz bearbeitet.

Es werden Strategien vermittelt, die mündlich wie schriftlich eine Verständigung trotz noch geringer Sprachkenntnisse ermöglichen. Außerdem werden Möglichkeiten aufgezeigt, den Lernprozess eigenverantwortlich effektiver zu gestalten und damit die eigene Lernfähigkeit zu verbessern. Die Studierenden üben soziale und interkulturelle kommunikative Kompetenz durch kooperatives Handeln und Mediation (auch online).

Im Unterricht wird zugleich auf die grammatikalischen und phonetischen Unterschiede zwischen Sprachvarietäten des Portugiesisch eingegangen.

### **Intended Learning Outcomes:**

Dieses Modul orientiert sich am Niveau A2 des GER.

Nach Abschluss dieses Moduls sind die Studierenden in der Lage im Gespräch einfache Sätze und Redewendungen zu einem erweiterten Spektrum an vertrauten Themen zu verstehen und zu gebrauchen. Dabei handelt es sich um grundlegende Informationen zu alltäglichen, oder studien- bzw. berufsrelevanten Themen unter Einbeziehung landeskundlicher Aspekte.

Sie können beispielsweise sich und andere Personen, die persönliche Wohnsituation, Gesundheitszustand, Freizeitverhalten und berufliche Situation im Präsens oder Perfekt beschreiben. Sie können Vorschläge machen und reagieren, Informationen austauschen und Ratschläge geben.

Sie sind in der Lage, mit Hilfe feststehender Wendungen kurze, informative Texte oder Mitteilungen zu verfassen. Es werden Haupt- und Nebensätze verwendet, die durch eine Reihe von Bindewörtern kontextadäquat verbunden werden.

Die Studierenden können in Gesprächen eine unterstützende Rolle übernehmen, sofern andere Teilnehmer/innen an Gesprächen langsam sprechen und einer oder mehrere von ihnen einem dabei helfen, etwas beizutragen und Vorschläge zu machen. Sie können wichtige Informationen aus klar strukturierten, kurzen, einfachen Informationstexten übermitteln, sofern die Texte konkrete, vertraute Themen betreffen und in einfacher Alltagssprache verfasst sind.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner- und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Dadurch wird die Interaktion und Mediation mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln, unter Berücksichtigung der sozialen und interkulturellen Kompetenz. Lernautonomie und Medienkompetenz werden angestrebt.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online.

**Reading List:**

Lehrbuch (wird in der LV bekannt gegeben);

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Portugiesisch A2.2 (Seminar, 2 SWS)

de Sena Lang J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0809: Portuguese B1.1 | Portugiesisch B1.1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht. Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bestandene Abschlussklausur oder gesicherte Kenntnisse der Niveau A2.

#### Content:

In diesem Modul werden Kenntnisse in Fremdsprache Portugiesisch unter Berücksichtigung plurikultureller, plurilingualler, landeskundlicher und studienbezogener Aspekte, die es den Studierenden ermöglichen, sich in vertrauten Situationen (Studium, Arbeit, Freizeit und Familie) und zu Themen von allgemeinem Interesse wie z. B. Konsum, Zukunft, Umwelt und Gesellschaft, selbständig und sicher in der Zielsprache zu verständigen, wenn Standardsprache der verschiedenen Varietäten des Portugiesisch verwendet wird.

Die Studierenden wiederholen und ergänzen elementare Aspekte der Grammatik wie den Gebrauch der Zeiten und der Präpositionen. Es werden auch gängige Redemittel bei Argumentation vermittelt und geübt. Sie lernen/üben den Gebrauch reflexiver Verben und das Passiv, wie man bestimmte Haltungen, Kenntnisse, Warnungen, Meinungen, Ziele und



Bewertungen ausdrückt; wie man Empfehlungen und Ratschläge gibt; wie man die persönliche Auslegung eines Gedankens erklärt; wie man in der Gruppe über ein Thema diskutiert, um Erklärungen bittet und sich auf das Gesagte bezieht.

Es werden Möglichkeiten aufgezeigt, den Lernprozess eigenverantwortlich effektiver zu gestalten und damit die eigene Lernfähigkeit zu verbessern. Die Studierenden üben soziale und interkulturelle kommunikative Kompetenz durch kooperatives Handeln und Mediation (auch online).

Im Unterricht wird zugleich auf die grammatikalischen und phonetischen Unterschiede zwischen Sprachvarietäten des Portugiesisch eingegangen.

### **Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau B1.1 des GER.

Nach Abschluss des Moduls sind die Studierenden in der Lage sich in den meisten Situationen, denen man in Studium, Beruf und Freizeit im Sprachgebiet begegnet, sicher zu verständigen und zu alltäglichen Themen eine persönliche Meinung äußern und widersprechen bzw. für und gegen etwas argumentieren.

Sie können sich über kulturelle Unterschiede und Sprache austauschen; Ratschläge, Warnungen und Meinungen aussprechen und schreiben; die meisten Situationen bewältigen, denen man auf Reisen und im Sprachgebiet begegnet; über Erfahrungen und Ereignisse berichten, Träume, Hoffnungen und Ziele beschreiben und dies auch begründen oder erklären; über persönliche Themen, und zu Ihrem Studenumfeld, kurze Texte schreiben.

Die Studierenden können andere Menschen einladen, ihr Fachwissen, ihre eigenen Erfahrungen und Sichtweise einzubringen. Sie können Informationen in klaren, gut strukturierten Texten zu Themen übermitteln, die ihnen vertraut oder von persönlichem oder aktuellem Interesse sind, obwohl der begrenzte Wortschatz gelegentlich zu Formulierungsproblemen führen kann.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner- und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Dadurch wird die Interaktion und Mediation mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln, unter Berücksichtigung der sozialen und interkulturellen Kompetenz. Lernautonomie und Medienkompetenz werden angestrebt.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor-und Nacharbeitung) festigen das Gelernte.

### **Media:**

angefertigte/zusammengestellte Lehrmaterialien; multimedial gestütztes Lehr- und Lernmaterial, auch online.

**Reading List:**

Vom Kursleiter selbst angefertigte / zusammengestellte Übungen und Materialien; Auszüge aus kopierbaren Lehrmaterialien; Online-Materialien

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Portugiesisch B1.1 (Seminar, 2 SWS)

Werkhausen R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0903: Russian A2.1 | Russisch A2.1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Version 1: In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Lese- und Hörverstehen sowie zur freien Textproduktion und wird in Form von kompetenz- und handlungsorientierten kumulativen Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

Version 2: Schriftliche Abschlussklausur (keine Hilfsmittel erlaubt). Prüfungsdauer: 90 Minuten. In der schriftlichen Prüfung werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhaltet Fragen zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Leseverstehen sowie Aufgaben zur freien Textproduktion. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Erfolgreiche Teilnahme an der Stufe A1.2 oder vergleichbare Sprachkenntnisse.

#### Content:

In diesem Modul werden Grundkenntnisse der Fremdsprache Russisch vermittelt. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt. Die Studierenden lernen Informationen zu erfragen und Auskunft zu geben, Pläne/Absichten zu äußern und diese kurz zu begründen, über Vorlieben, Interessen und Erfahrungen zu sprechen. Die Studierenden üben zum Beispiel Einkaufsdialoge im Kaufhaus zu führen, über ihre Kleiderwahl zu sprechen, Reiseerlebnisse zu schildern, sich auszutauschen, wo und wann man gern seinen Urlaub verbringt, wo man gern wohnt. Es werden kommunikative Situationen geübt, die auf einen Aufenthalt im Zielland

vorbereiten. Dazu werden die notwendigen grammatikalischen Themen behandelt und Lernstrategien vermittelt, die eine erfolgreiche Gestaltung des weiteren Lernprozesses in der Fremdsprache Russisch ermöglichen.

**Intended Learning Outcomes:**

Dieses Modul orientiert sich am Niveau A2 des Gemeinsamen Europäischen Referenzrahmens (GER). Nach Bestehen des Moduls sind die Studierenden in der Lage, sich in einfachen, routinemäßigen Gesprächssituationen zu verständigen, in denen es um einen direkten Austausch von Informationen über vertraute und geläufige Dinge geht. Die Studierenden können die Bedeutung von kurzen, klaren und deutlich artikulierten Mitteilungen und Durchsagen erfassen. Sie sind in der Lage, häufig gebrauchte Ausdrücke anzuwenden und Sätze zu formulieren, die mit Bereichen von ganz unmittelbarer Bedeutung zusammenhängen.

**Teaching and Learning Methods:**

Kommunikatives und handlungsorientiertes Erarbeiten der Inhalte; gezielte Hör-, Lese-, Schreib- und Sprechübungen; Einzel-, Partner- und Gruppenarbeit; kontrolliertes Selbstlernen mit vorgegebenen Materialien; Vorbereitung einer Präsentation in der Zielsprache; selbständige Recherchen zu den vorgegebenen Themen. Freiwillige Hausaufgaben festigen das Gelernte.

**Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online.

**Reading List:**

Lehrbuch (wird in der LV bekannt gegeben); multimedial gestütztes Lehr- und Lernmaterial (wird in der LV bekannt gegeben)

Vom Kursleiter selbst angefertigte / zusammengestellte Übungen; Auszüge aus kopierbaren Lehrmaterialien; Online-Materialien

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Russisch A2.1 (Seminar, 2 SWS)

Legkikh V

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ0904: Russian A2.2 | Russisch A2.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Version 1: In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Anwendung von Wortschatz und Grammatik, zu Lese- und Hörverstehen sowie zur freien Textproduktion und wird in Form von kompetenz- und handlungsorientierten kumulativen Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

Version 2: Schriftliche Abschlussklausur (keine Hilfsmittel erlaubt). Prüfungsdauer: 90 Minuten. In der schriftlichen Prüfung werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhaltet Fragen zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Leseverstehen sowie Aufgaben zur freien Textproduktion. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Erfolgreiche Teilnahme an der Stufe A2.1 oder vergleichbare Sprachkenntnisse.

#### Content:

In diesem Modul werden Grundkenntnisse der Fremdsprache Russisch vermittelt. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt. Die Studierenden üben, einfache Gespräche in alltäglichen Kommunikationssituationen zu beginnen und in Gang zu halten sowie sich über vertraute Themengebiete zu äußern. Die Studierenden lernen zum Beispiel sich über Studium/Arbeitsalltag auszutauschen, die Wohnsituation zu beschreiben und Wegbeschreibungen zu geben. Es werden kommunikative Situationen geübt, die auf einen Aufenthalt im Zielland vorbereiten. Dazu werden die notwendigen grammatikalischen

Themen behandelt und Lernstrategien vermittelt, die eine erfolgreiche Gestaltung des weiteren Lernprozesses in der Fremdsprache Russisch ermöglichen.

**Intended Learning Outcomes:**

Dieses Modul orientiert sich am Niveau A2 des Gemeinsamen Europäischen Referenzrahmens (GER). Nach Bestehen des Moduls sind die Studierenden in der Lage, sich in einfachen, routinemäßigen Gesprächssituationen zu verständigen, in denen es um einen direkten Austausch von Informationen über vertraute und geläufige Dinge geht. Die Studierenden können die Bedeutung von kurzen, klaren und deutlich artikulierten Mitteilungen und Durchsagen erfassen. Sie sind in der Lage, häufig gebrauchte Ausdrücke anzuwenden und Sätze zu formulieren, die mit Bereichen von ganz unmittelbarer Bedeutung zusammenhängen.

**Teaching and Learning Methods:**

Kommunikatives und handlungsorientiertes Erarbeiten der Inhalte; gezielte Hör-, Lese-, Schreib- und Sprechübungen; Einzel-, Partner- und Gruppenarbeit; kontrolliertes Selbstlernen mit vorgegebenen Materialien; Vorbereitung einer Präsentation in der Zielsprache; selbständige Recherchen zu den vorgegebenen Themen. Freiwillige Hausaufgaben festigen das Gelernte.

**Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online.

**Reading List:**

Lehrbuch (wird in der LV bekannt gegeben) (wird in der LV bekannt gegeben)

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Russisch A2.2 (Seminar, 2 SWS)

Tagieva T

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ1003: Swedish B1 | Schwedisch B1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht.

Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bestandene Abschlussklausur A2

#### Content:

In diesem Modul werden Kenntnisse der Fremdsprache Schwedisch erarbeitet, die es den Studierenden ermöglichen, sich in vertrauten Situationen (Studium, Arbeit, Freizeit und Familie) und zu Themen von allgemeinem Interesse wie z. B. Film, Musik, Sport selbständig in der Zielsprache zu äußern, wenn Standardsprache verwendet wird.

Kommunikationsmöglichkeiten (Vokabular, Redewendungen, Dialogmuster etc.) zu den genannten Bereichen, ergänzen das Repertoire an Nebensätzen.

**Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau B1 des GER. Der/Die Studierende erlangt Kenntnisse in der Fremdsprache Schwedisch auf standardsprachlichem Niveau unter Berücksichtigung interkultureller, landeskundlicher und studienbezogener Aspekte.

Nach Abschluss des Moduls kann der/die Studierende sich in den meisten Situationen, denen man in Studium oder in der Freizeit im Sprachgebiet begegnet, sicher verständigen und zu alltäglichen Themen eine persönliche Meinung äußern und widersprechen bzw. für und gegen etwas argumentieren.

**Teaching and Learning Methods:**

Kommunikatives und handlungsorientiertes Erarbeiten der Inhalte; gezielte Hör-, Lese-, Schreib- und Sprechübungen; Einzel-Partner- und Gruppenarbeit; Kontrolliertes Revidieren der Grundgrammatik mit vorgegebenen (online-)Materialien; Referieren nach vorgegebenen Kriterien; diskutieren in Gruppen zu vorbereiteten Themen und nach vorgegebenen Kommunikationsmustern. Freiwillige Hausaufgaben zur Vor- und Nachbearbeitung festigen das Gelernte.

**Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial

**Reading List:**

Lehrbuch (wird in der LV bekannt gegeben); multimedial gestütztes Lehr- und Lernmaterial

**Responsible for Module:****Courses (Type of course, Weekly hours per semester), Instructor:**

Schwedisch B1 (Seminar, 2 SWS)

Matyas E, Thunstedt C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### SZ1202: Spanish A2.1 | Spanisch A2.1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Rezeption (Lese- und Hörverstehen) sowie zur Produktion (Wortschatz und Grammatik sowie freie Textproduktion) und werden in Form von kommunikativen kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Produktion wird anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei abgehalten. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse der Stufe A1.  
Einstufungstest mit Ergebnis A2.1.

#### Content:

In diesem Modul werden Grundkenntnisse in der Fremdsprache Spanisch vermittelt, die es den Studierenden ermöglichen, sich in alltäglichen Grundsituationen zurechtzufinden, z.B. Freizeitaktivitäten, auf Reisen, im Restaurant, unter Kommilitonen, Freunden und Nachbarn, Austausch von Erfahrungen etc. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt.

Die grammatikalischen Strukturen werden weiter aufgebaut, wie z.B. die Verwendung von den Vergangenheiten pretérito perfecto - pretérito indefinido, ser und estar, unbetonte Personal Pronomen etc.

Es werden Strategien vermittelt, die mündlich wie schriftlich eine Verständigung trotz noch geringer Sprachkenntnisse ermöglichen.

### **Intended Learning Outcomes:**

Dieses Modul orientiert sich am Niveau A2 „Elementare Sprachverwendung“ der GER. Nach der Teilnahme an der Modulveranstaltung sind die Studierenden in der Lage, die Bedeutung von kurzen, klaren und deutlich artikulierten Mitteilungen und Durchsagen zu erfassen. Die Kommunikation ist im Rahmen von einfachen, routinemäßigen Kontexten möglich. Der Austausch von Informationen erfolgt über kurze Dialoge mit verschiedenen Zeitbezügen (z.B. Gegenwart, Vergangenheit, einfaches Futur) und umfasst einfache Satzgefüge mit beschränkten Strukturen zu vertrauten Tätigkeiten. Der/Die Studierende kann einfache Fragen zu Inhalten stellen und auch beantworten. Gespräche und Dialoge sind kurz, zeitlich beschränkt und orientieren sich inhaltlich an Kontexten, wie z.B. Familie, Freunde, Lebens- und Wohnraum, Reisen. Die Studierenden können kurze Texte oder Briefe lesen und verstehen, wenn diese einen häufig gebrauchten Wortschatz und bekannte Strukturen beinhaltet und wenn darin vertraute Informationen zu finden sind. Er/Sie ist in der Lage mithilfe feststehender Wendungen kurze, einfache Mitteilungen oder persönliche Briefe zu verfassen.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechaufgaben in Einzel-, Partner und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Durch die Kombination dieser Aufgaben wird die Interaktion mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Spanisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online.

### **Reading List:**

Lehrbuch (wird in der Lehrveranstaltung bekanntgegeben).

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Spanisch A2.1 (Seminar, 2 SWS)

Barreda C, Galan Rodriguez F, Guerrero Madrid V, Hernandez Zarate M, Mayea von Rimscha A, Rey Pereira C, Sosa Hernando E, Tapia Perez T

Blockkurs Spanisch A2.1 (Seminar, 2 SWS)

Guerrero Madrid V, Tapia Perez T, Zuniga Chinchilla L

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ1203: Spanish A2.2 | Spanisch A2.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Rezeption (Lese- und Hörverstehen) sowie zur Produktion (Wortschatz und Grammatik sowie freie Textproduktion) und werden in Form von kommunikativen kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Produktion wird anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei abgehalten. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse der Stufe A2.1.  
Einstufungstest mit Ergebnis A2.2.

#### Content:

In diesem Modul werden weitere Grundkenntnisse der Fremdsprache Spanisch vermittelt, die den Studierenden ermöglichen, sich in alltäglichen Grundsituationen zurechtzufinden. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt. Die Studierenden lernen/üben u.a. Anweisungen und Ratschläge zu geben; Situationen und Ereignisse in der Vergangenheit zu schildern; Geschichten zu erzählen; über die Wohnungssuche zu sprechen. Dazu werden entsprechende hierfür notwendige grammatikalische Themen behandelt wie die Verwendung und Kontrast der Zeiten der Vergangenheit, pretérito imperfecto und pretérito indefinido, das Imperativ, das Gebrauch von Präpositionen etc. Es werden Strategien vermittelt, die eine Verständigung trotz noch geringer Sprachkenntnisse (in alltäglichen Grundsituationen) ermöglichen.

### **Intended Learning Outcomes:**

Dieses Modul orientiert sich am Niveau A2 „Elementare Sprachverwendung“ des GER. Nach der Teilnahme an der Modulveranstaltung sind die Studierenden in der Lage vertraute Sätze und Redewendungen zu einem erweiterten Spektrum an Themen zu verstehen. Dabei handelt es sich um grundlegende Informationen zu alltäglichen oder Studien- bzw. berufsrelevanten Themen. Sie erfassen die Bedeutung von kurzen, klaren und deutlich artikulierten Mitteilungen und Durchsagen. Der Austausch von Informationen erfolgt kurz aber mühelos über eine Reihe bekannter Äußerungen zu vertrauten Tätigkeiten und Themen. Die Studierenden können sich aktiv in kurzen Interaktionen, die über einen beschränkten zeitlichen Umfang gehen, zu bekannten Themen einbringen. Er/Sie kann längere Texte und Briefe zu vertrauten Themen verstehen, in denen gängige aber einfache alltags- oder berufsbezogene Sprache verwendet wird und in denen vorhersehbare Informationen zu finden sind. Der/Die Studierende ist in der Lage, mithilfe feststehender Wendungen kurze, informative Texte oder Mitteilungen zu verfassen. Es werden Haupt- und Nebensätze verwendet, die durch eine Reihe von Bindewörtern kontextadäquat verbunden werden.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechaufgaben in Einzel-, Partner und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Durch die Kombination dieser Aufgaben wird die Interaktion mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Spanisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online.

### **Reading List:**

Lehrbuch (wird in der Lehrveranstaltung bekanntgegeben).

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Spanisch A2.2 (Seminar, 2 SWS)

Gomez Cabornero S, Guerrero Madrid V, Hernandez Zarate M, Mayea von Rimscha A, Rey Pereira C, Rodriguez Garcia M

Blockkurs Spanisch A2.2 (Seminar, 2 SWS)

Guerrero Madrid V

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ12031: Spanish A2.1 + A2.2 | Spanisch A2.1 + A2.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6                   | <b>Total Hours:</b><br>180          | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Rezeption (Lese- und Hörverstehen) sowie zur Produktion (Wortschatz und Grammatik sowie freie Textproduktion) und werden in Form von kommunikativen kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Produktion wird anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei abgehalten. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse der Stufe A1.  
Einstufungstest mit Ergebnis A2.1.

#### Content:

In diesem Modul werden weitere Grundkenntnisse der Fremdsprache Spanisch vermittelt, die den Studierenden ermöglichen, sich in alltäglichen Grundsituationen zurechtzufinden. Dabei werden interkulturelle und landeskundliche Aspekte berücksichtigt. Die Studierende lernen/üben u.a.: wie man eine Wohnung sucht; wie man Erfahrungen austauscht; wie man Anweisungen, und Ratschläge gibt; wie man Situationen und Ereignisse in der Vergangenheit schildert; wie man Geschichten erzählt. Dazu werden entsprechende hierfür notwendige grammatikalische Themen behandelt und vertieft. Es werden Strategien vermittelt, die eine Verständigung trotz noch geringer Sprachkenntnisse (in alltäglichen Grundsituationen) ermöglichen.

### **Intended Learning Outcomes:**

Dieses Modul orientiert sich am Niveau A2 „Elementare Sprachverwendung“ des GER. Nach der Teilnahme an der Modulveranstaltung sind die Studierenden in der Lage, vertraute Sätze und Redewendungen zu einem erweiterten Spektrum an Themen zu verstehen. Dabei handelt es sich um grundlegende Informationen zu alltäglichen oder Studien- bzw. berufsrelevanten Themen. Sie erfassen die Bedeutung von kurzen, klaren und deutlich artikulierten Mitteilungen und Durchsagen. Der Austausch von Informationen erfolgt kurz aber mühelos über eine Reihe bekannter Äußerungen zu vertrauten Tätigkeiten und Themen. Die Studierenden können sich aktiv in kurzen Interaktionen, die über einen beschränkten zeitlichen Umfang gehen, zu bekannten Themen einbringen. Er/Sie kann längere Texte und Briefe zu vertrauten Themen verstehen, in denen gängige aber einfache alltags- oder berufsbezogene Sprache verwendet wird und in denen vorhersehbare Informationen zu finden sind. Der/Die Studierende ist in der Lage mithilfe feststehender Wendungen kurze, informative Texte oder Mitteilungen zu verfassen. Es werden Haupt- und Nebensätze verwendet, die durch eine Reihe von Bindewörtern kontextadäquat verbunden werden.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechaufgaben in Einzel-, Partner und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Durch die Kombination dieser Aufgaben wird die Interaktion mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Spanisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online.

### **Reading List:**

Lehrbuch (wird in der Lehrveranstaltung bekanntgegeben).

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Spanisch A2.1 + A2.2 (intensiv) (Seminar, 4 SWS)

Gonzalez Sainz C, Guerrero Madrid V, Henche I, Mayea von Rimscha A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### SZ1209: Spanish C1 - current issues in Spain and Latin America | Spanisch C1 - La actualidad en España y América Latina

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                  |
|-----------------------------------------|-------------------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Rezeption (Lese- und Hörverstehen) sowie zur Produktion (Wortschatz und Grammatik sowie freie Textproduktion) und werden in Form von kommunikativen kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Produktion wird anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei abgehalten. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse der Stufe B2.2.

Einstufungstest mit Ergebnis C1.1.

#### Content:

In diesem Modul werden den Studierenden kulturelle, soziopolitische und/oder geschichtliche Kenntnisse über die spanischsprachigen Länder vermittelt, die sie in die Lage versetzen, unter Einbeziehung interkultureller Aspekte zu kommunizieren und zu handeln. Diese Veranstaltung bietet einen Querschnitt durch die Kultur und Gesellschaft Spaniens und Lateinamerika, indem gesellschaftliche Tendenzen anhand aktueller Zeitungsartikeln, Literatur (Kurzerzählungen), Essays, Filme etc., diskutiert werden. Es soll den Studierenden eine Vertiefung in das „Fremdverstehen“ der gesamten spanischsprachigen Welt ermöglichen und somit auch die interkulturelle Kompetenz erhöht werden. Es wird ein erweitertes Spektrum an Kommunikationsmöglichkeiten zu aktuellen Themen erarbeitet und Aspekte der Grammatik wiederholt und ergänzt.

In diesem Modul haben die Studierenden die Gelegenheit, eine kurze Präsentation eigenverantwortlich zu gestalten und vorzutragen sowie anschließend auf Fragen zur eigenen Präsentation zu antworten.

### **Intended Learning Outcomes:**

Dieses Modul orientiert sich an Niveau C1 „Kompetente Sprachverwendung“ des Gemeinsamen Europäischen Referenzrahmens für Sprachen des Europarats.

Nach Abschluss des Moduls kann der/die Studierende ein breites Spektrum anspruchsvoller, längerer Texte verstehen und auch implizite Bedeutungen erfassen. Er/Sie kann sich spontan und fließend ausdrücken, ohne öfter deutlich erkennbar nach Worten suchen zu müssen. Er/Sie kann die Sprache im gesellschaftlichen und beruflichen Leben oder in Ausbildung und Studium wirksam und flexibel gebrauchen. Die Studierenden können sich klar, strukturiert und ausführlich zu komplexen Sachverhalten äußern und dabei verschiedene Mittel zur Textverknüpfung angemessen verwenden. Er/Sie kann ihre Gedanken und Meinungen präzise ausdrücken und ihre eigenen Beiträge geschickt mit denen anderer verknüpfen.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechaufgaben in Einzel-, Partner und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Durch die Kombination dieser Aufgaben wird die Interaktion mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Spanisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

Referieren und Präsentieren nach vorgegebenen Kriterien; moderierte (Rollen-) Diskussionen; Eigenständiges Referieren und Präsentieren akademischer und gesamtgesellschaftlicher Inhalte zu vorgegebenen Themen.

### **Media:**

Multimedial gestütztes Lehr- und Lernmaterial, auch online.

### **Reading List:**

Wird in der Lehrveranstaltung bekanntgegeben.

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Spanisch C1 La actualidad en España y América Latina (Seminar, 2 SWS)

Martinez Wahnnon A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ1212: Spanish C1 - Spain and Latin America - Yesterday and Today | Spanisch C1 - España y América Latina ayer y hoy

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                  |
|-----------------------------------------|-------------------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Rezeption (Lese- und Hörverstehen) sowie zur Produktion (Wortschatz und Grammatik sowie freie Textproduktion) und werden in Form von kommunikativen kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Produktion wird anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei abgehalten. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse der Stufe B2.2.

Einstufungstest mit Ergebnis C1.1.

#### Content:

In diesem Modul werden Kenntnisse in der Fremdsprache Spanisch erarbeitet, die es den Studierenden ermöglichen, mündlich wie schriftlich in Themenbereichen aus Alltag, Beruf, Kultur, Gesichte, Politik der spanischsprachigen Länder situationsadäquat zu handeln (agieren und reagieren). Anhand ausgewählter Presseartikeln, Literatur, etc., werden soziokulturelle Zusammenhänge aktueller Themen reflektiert. Es werden Kenntnisse in den benannten Bereichen vertieft und Aspekte der Grammatik wiederholt und ergänzt. In diesem Modul haben die Studierenden die Gelegenheit, eine kurze Präsentation eigenverantwortlich zu gestalten und vorzutragen sowie anschließend auf Fragen zur eigenen Präsentation zu antworten.

### **Intended Learning Outcomes:**

Dieses Modul orientiert sich an Niveau C1 „Kompetente Sprachverwendung“ des GER. Nach der Teilnahme an der Modulveranstaltung kann der/die Studierende auf sehr hohem Niveau in unterschiedlichsten Situationen mündlich und schriftlich kommunizieren. Er/Sie ist in der Lage, die Fremdsprache sowohl im Auslandsstudium als auch im Beruf wirksam und flexibel zu gebrauchen. Die Studierenden können komplexe Sachverhalte ausführlich darstellen und dabei Themenpunkte miteinander verbinden, bestimmte Aspekte besonders ausführen und ihren Beitrag angemessen abschließen. Er/Sie kann ein breites Spektrum anspruchsvoller, längerer Texte verstehen und auch implizite Bedeutungen erfassen. Er/Sie kann sich spontan und fließend ausdrücken, ohne öfter deutlich erkennbar nach Worten suchen zu müssen. Er/Sie kann sich klar, strukturiert und ausführlich zu komplexen Sachverhalten äußern und dabei verschiedene Mittel zur Textverknüpfung angemessen verwenden.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezieltem Hör-, Lese-, Schreib- und Sprechübungen in Einzel-, Partner und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Durch die Kombination dieser Übungen wird die Interaktion mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Spanisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern. Durch kontrolliertes Revidieren grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Kenntnisse vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

Referieren und Präsentieren nach vorgegebenen Kriterien; moderierte (Rollen-) Diskussionen; Eigenständiges Referieren und Präsentieren akademischer und gesamtgesellschaftlicher Inhalte zu vorgegebenen Themen.

### **Media:**

Multimedial gestütztes Lehr- und Lernmaterial, auch online.

### **Reading List:**

Wird in der Lehrveranstaltung bekanntgegeben.

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ1216: Spanish B1.2 | Spanisch B1.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Rezeption (Lese- und Hörverstehen) sowie zur Produktion (Wortschatz und Grammatik sowie freie Textproduktion) und werden in Form von kommunikativen kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Produktion wird anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei abgehalten. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse der Stufe B1.1.  
Einstufungstest mit Ergebnis B1.2.

#### Content:

In diesem Modul werden Kenntnisse in der Fremdsprache Spanisch erarbeitet, die es den Studierenden ermöglichen, (sich) in vertrauten Situationen, z.B. in Studium, Arbeit, Freizeit und Familie, und zu Themen von allgemeinem Interesse wie Film, Musik, Sport u.a. selbständig und sicher in der Zielsprache zu operieren/bewegen/verständigen, wenn Standardsprache verwendet wird. Sie erweitern Ihren Wortschatz sowie festigen und vertiefen die bisher erlernten grammatischen Schwerpunkte der spanischen Sprache. Dabei werden interkulturelle, landeskundliche und studienbezogene Aspekte berücksichtigt. Die Studierenden vertiefen ihre Kenntnisse anhand verschiedener aktueller Themen des spanischsprachigen Raums. Dazu werden entsprechende, hierfür notwendige grammatische Themen und Wortschatz behandelt.

### **Intended Learning Outcomes:**

Dieses Modul orientiert sich am Niveau B1 „Selbständige Sprachverwendung“ des GER. Der/Die Studierende erlangt vertiefte Kenntnisse in der Fremdsprache Spanisch auf standardsprachlichen Niveau unter Berücksichtigung interkultureller, landeskundlicher und studienbezogener Aspekte. Nach Abschluss des Moduls kann der/die Studierende sich in den meisten Situationen, denen man im Studium oder Beruf, Freizeit und auf Reisen im Sprachgebiet begegnet, sicher verständigen. Er/Sie ist in der Lage, wesentliche Inhalte in einfachen, authentischen Sachtexten, Fernseh- oder Radiosendungen und literarischen Texten zu verstehen und wiederzugeben und sich spontan an Gesprächen zu vertrauten Themen von allgemeinem Interesse zu beteiligen. Der/Die Studierende kann einfache formelle und längere persönliche Briefe und Texte verfassen, strukturiert zu einem alltäglichen Thema von persönlichem Interesse referieren und schriftlich eine logisch begründete Stellungnahme zu einem aktuellen Thema verfassen, wenn Hilfestellung gegeben wird.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechaufgaben in Einzel-, Partner und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Durch die Kombination dieser Aufgaben wird die Interaktion mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Spanisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online.

### **Reading List:**

Lehrbuch (wird in der Lehrveranstaltung bekanntgegeben).

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Spanisch B1.2 (Seminar, 2 SWS)

Galan Rodriguez F, Gomez Cabornero S, Hernandez Zarate M, Rey Pereira C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ1217: Spanish B2.2 | Spanisch B2.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Rezeption (Lese- und Hörverstehen) sowie zur Produktion (Wortschatz und Grammatik sowie freie Textproduktion) und werden in Form von kommunikativen kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Produktion wird anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei abgehalten. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse der Stufe B2.1.  
Einstufungstest mit Ergebnis B2.2.

#### Content:

In diesem Modul werden Kenntnisse in der Fremdsprache Spanisch erarbeitet, die es den Studierenden ermöglichen, aktiv und weitgehend flüssig über Themen von allgemeinem Interesse oder in vertrauten Fachgebieten mit einem Muttersprachler zu kommunizieren und eine Argumentation strukturiert auszuführen. Ein besonderes Augenmerk wird in diesem Modul auf die Entwicklung von Lesestrategien allgemeiner, akademischer und fachbezogener Texten, auf Wortschatzarbeit sowie die Befähigung zur Entwicklung von Hörstrategien gelegt. Zur Festigung der mündlichen und schriftlichen Fertigkeit werden Schwerpunkte der Grammatik (z.B. *contraste de pasados, indicativo/subjuntivo, estilo indirecto, oraciones subordinadas complejas* 2) erarbeitet, wiederholt und vertieft.



In diesem Modul haben die Studierenden die Gelegenheit, eine kurze Präsentation eigenverantwortlich zu gestalten und vorzutragen sowie anschließend auf Fragen zur eigenen Präsentation zu antworten.

### **Intended Learning Outcomes:**

Dieses Modul orientiert sich am Niveau B2 „Selbständige Sprachverwendung“ des GER. Der/die Studierende erlangt Kenntnisse in der Fremdsprache Spanisch auf schriftsprachlichem Niveau unter Berücksichtigung interkultureller, landeskundlicher und studienbezogener Aspekte. Er/Sie kann mühelos unterschiedlichste Texte, Artikel und Berichte aus Fachbüchern, Zeitschriften und Magazinen zu einem breiten Spektrum an Themen lesen und verstehen. Er/Sie kann in den Texten verschiedene Meinungsbilder, Standpunkte und Haltungen erkennen. Er/Sie ist in der Lage, zeitgenössische Prosatexte zu lesen. Der/Die Studierende kann längere Redebeiträge und Vorträge mühelos verstehen und komplexer Argumentation folgen, sofern sie klar vorgetragen werden. Der/Die Studierende ist in der Lage, klare und detaillierte Texte zu verschiedenen Themen, die von besonderem Interesse für ihn/sie sind oder zu seinem/ihrer Fachgebiet gehören zu verfassen und dabei kohärent zu argumentieren und fachspezifisches Vokabular zu benutzen. Er/Sie kann die eigenen Ansichten und Standpunkte begründen und verteidigen, seine/ ihre Argumentation logisch aufbauen und verbinden sowie Vor- und Nachteile bezüglich einer Entscheidung darlegen. Er/Sie kann sich spontan und fließend verständigen. Er/Sie kann zu vielen Themen aus seinen/ihren Interessen- oder Fachgebieten klar und strukturiert in mündlicher Form kommunizieren.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechaufgaben in Einzel-, Partner und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Durch die Kombination dieser Aufgaben wird die Interaktion mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Spanisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online.

### **Reading List:**

Lehrbuch (wird in der Lehrveranstaltung bekanntgegeben).

### **Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Spanisch B2.2 (Seminar, 2 SWS)

Angulo Reyes A, Tapia Perez T

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ1218: Spanish B1.1 | Spanisch B1.1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Rezeption (Lese- und Hörverstehen) sowie zur Produktion (Wortschatz und Grammatik sowie freie Textproduktion) und werden in Form von kommunikativen kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Produktion wird anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei abgehalten. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse der Stufe A2.2.  
Einstufungstest mit Ergebnis B1.1.

#### Content:

In diesem Modul werden Kenntnisse in der Fremdsprache Spanisch erarbeitet, die es den Studierenden ermöglichen, (sich) in vertrauten Situationen, z.B. in Studium, Arbeit, Freizeit und Familie, und zu Themen von allgemeinem Interesse selbständig und sicher zu operieren/bewegen/verständigen, wenn Standardsprache verwendet wird. Sie erweitern Ihren Wortschatz sowie festigen und vertiefen die bisher erlernten grammatikalischen Schwerpunkte der spanischen Sprache. Die Studierenden lernen/üben u.a. wie man Vermutungen anstellt; über biografische und historische Ereignisse spricht; wie man Wünsche und Gefühle ausdrückt. Dazu werden entsprechende, hierfür notwendige grammatische Themen behandelt.

### **Intended Learning Outcomes:**

Dieses Modul orientiert sich am Niveau B1 „Selbständige Sprachverwendung“ des GER. Der/Die Studierende erlangt in diesem Modul vertiefte Kenntnisse in der Fremdsprache Spanisch mit allgemeinsprachlicher Orientierung unter Berücksichtigung interkultureller und landeskundlicher Aspekte. Nach erfolgreicher Teilnahme am Modul kann der/die Studierende sich in den ihm/ihr vertrauten Situationen, denen man im Studium oder Beruf, Freizeit und auf Reisen im Sprachgebiet begegnen kann, sicher verständigen. Der/Die Studierende ist in der Lage, wesentliche Inhalte in einfachen authentischen Texten aus alltäglichen Bereichen zu verstehen, und sich spontan an Gesprächen zu vertrauten Themen zu beteiligen. Die Studierenden können mündlich wie schriftlich über Erfahrungen, Gefühle und Ereignisse einfach und zusammenhängend berichten und zu vertrauten Themen eine persönliche Meinung äußern und argumentieren.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechaufgaben in Einzel-, Partner und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Durch die Kombination dieser Aufgaben wird die Interaktion mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Spanisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online.

### **Reading List:**

Lehrbuch (wird in der Lehrveranstaltung bekanntgegeben).

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Spanisch B1.1 (Seminar, 2 SWS)

Barreda C, Galan Rodriguez F, Guerrero Madrid V, Hernandez Zarate M, Nevado Cortes C, Sosa Hernando E

Blockkurs Spanisch B1.1 (Seminar, 2 SWS)

Sosa Hernando E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ1225: Spanish B1.1 + B1.2 | Spanisch B1.1 + B1.2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6                   | <b>Total Hours:</b><br>180          | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Rezeption (Lese- und Hörverstehen) sowie zur Produktion (Wortschatz und Grammatik sowie freie Textproduktion) und werden in Form von kommunikativen kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Produktion wird anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei abgehalten. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse der Stufe A2.2.  
Einstufungstest mit Ergebnis B1.1.

#### Content:

In diesem Modul werden Kenntnisse in der Fremdsprache Spanisch erarbeitet, die es den Studierenden ermöglichen, (sich) in vertrauten Situationen, z.B. in Studium, Arbeit, Freizeit und Familie, und zu Themen von allgemeinem Interesse wie Film, Musik, Sport u.a. selbständig und sicher in der Zielsprache zu operieren/bewegen/verständigen, wenn Standardsprache verwendet wird. Sie erweitern Ihren Wortschatz sowie festigen und vertiefen die bisher erlernten grammatischen Schwerpunkte der spanischen Sprache. Dabei werden interkulturelle, landeskundliche und studienbezogene Aspekte berücksichtigt. Die Studierenden vertiefen ihre Kenntnisse anhand verschiedener aktueller Themen des spanischsprachigen Raums. Dazu werden entsprechende, hierfür notwendige grammatische Themen und Wortschatz behandelt.

### **Intended Learning Outcomes:**

Dieses Modul orientiert sich am Niveau B1 „Selbstständige Sprachverwendung“ des GER. Der/Die Studierende erlangt vertiefte Kenntnisse in der Fremdsprache Spanisch auf standardsprachlichen Niveau unter Berücksichtigung interkultureller, landeskundlicher und studienbezogener Aspekte. Nach Abschluss des Moduls kann der/die Studierende sich in den meisten Situationen, denen man im Studium oder Beruf, Freizeit und auf Reisen im Sprachgebiet begegnet, sicher verständigen. Er/Sie ist in der Lage, wesentliche Inhalte in einfachen, authentischen Sachtexten, Fernseh- oder Radiosendungen und literarischen Texten zu verstehen und wiederzugeben und sich spontan an Gesprächen zu vertrauten Themen von allgemeinem Interesse zu beteiligen. Der/Die Studierende kann einfache formelle und längere persönliche Briefe und Texte verfassen, strukturiert zu einem alltäglichen Thema von persönlichem Interesse referieren und schriftlich eine logisch begründete Stellungnahme zu einem aktuellen Thema verfassen, wenn Hilfestellung gegeben wird.

### **Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechaufgaben in Einzel-, Partner und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Durch die Kombination dieser Aufgaben wird die Interaktion mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Spanisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor-und Nacharbeitung) festigen das Gelernte.

### **Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online.

### **Reading List:**

Lehrbuch (wird in der Lehrveranstaltung bekanntgegeben).

### **Responsible for Module:**

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Spanisch B1.1+B1.2 (intensiv) (Seminar, 2 SWS)

Garcia Garcia M, Lopez Agudo E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ1228: Spanish B2 - Spanish in Science and Technology | Spanisch B2 - Español para la Ciencia und Tecnología

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                  |
|-----------------------------------------|-------------------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhalten Aufgaben zur Rezeption (Lese- und Hörverstehen) sowie zur Produktion (Wortschatz und Grammatik sowie freie Textproduktion) und werden in Form von kommunikativen kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben abgehalten. Hilfsmittel erlaubt. Mündliche Produktion wird anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei abgehalten. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Gesicherte Kenntnisse der Stufe B2.2.

Einstufungstest mit Ergebnis C1.1.

#### Content:

In dieser LV werden Kenntnisse in der Fremdsprache Spanisch erarbeitet, die es den Studierenden ermöglichen, in Studium und Beruf annähernd flüssig über Themen des eigenen und eines fremden Fach- und Interessengebiets zu kommunizieren. Die Studierenden analysieren Strukturen, die in Fachtexten und fachlicher Kommunikation häufig auftreten. Sie erarbeiten einen umfangreichen Wortschatz zu einem breiten Spektrum an technischen Themen. Die Studierenden verwenden Strategien, die effizientes Hören und Lesen im Fach unterstützen. Grundlage der Erarbeitung der genannten Lerninhalte sind in erster Linie authentische Fachtexte. In dieser LV haben die Studierenden die Gelegenheit, eine kurze Präsentation zu gestalten, vorzutragen und anschließend auf Fragen zur eigenen Präsentation zu antworten.

**Intended Learning Outcomes:**

Dieser LV orientiert sich an Niveau B2 „Selbständige Sprachverwendung“ des GER. Nach der Teilnahme an der Lehrveranstaltung kann der/die Studierende den wesentlichen Inhalt von wissenschaftlichen Artikeln und Berichte sowie Texte aus dem eigenen Fach- und Interessengebiet selbständig verstehen und Standpunkte identifizieren. Er/Sie kann längeren Redebeiträge und Vorträgen sowohl zu aktuellen Themen als auch innerhalb seines/ihrer Fachgebietes folgen, sofern sie klar vorgetragen werden. Der/Die Studierende ist in der Lage zusammenhängende Texte fachsprachlichen Themen zu verfassen und dabei auch kohärent zu argumentieren und fachspezifisches Vokabular zu benutzen. Er/Sie kann zu vielen Themen aus seinem/ihrer Interessen- oder Fachgebiet klar und strukturiert referieren und argumentativ Stellung beziehen.

**Teaching and Learning Methods:**

Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechaufgaben in Einzel-, Partner und Gruppenarbeit kommunikativ und handlungsorientiert erarbeitet werden. Durch die Kombination dieser Aufgaben wird die Interaktion mit den Partnern unterstützt und gefordert. Die Studierenden erwerben Teamkompetenz durch kooperatives Handeln in gemischten Gruppen.

Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache Spanisch eigenverantwortlich und effektiver zu gestalten und damit die eigenen Lernfähigkeiten zu verbessern.

Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.

Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

**Media:**

Multimedial gestütztes Lehr- und Lernmaterial, auch online.

**Reading List:**

Wird im Kurs bekanntgegeben.

**Responsible for Module:****Courses (Type of course, Weekly hours per semester), Instructor:**

Spanisch B2 - Español para la ciencia y la tecnología (Seminar, 2 SWS)

Martinez Wahnnon A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### SZ1502: Danish A2 | Dänisch A2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Studien-/Prüfungsleistungen:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht.

Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bestandene Prüfungsleistungen A1

#### Content:

In diesem Modul werden erweiterte Kenntnisse der dänischen Sprache vermittelt, die es den Studierenden ermöglichen, sich in fast allen alltäglichen Kommunikationssituationen zurechtzufinden.

Geübt wird: erweitertes Basisvokabular um Beschreibungen und eigene Meinung bekannt zu geben, eigene Situation und Aktivitäten zu weitergeben, über das Wetter zu reden etc. Themen sind z.B. im Bereich Ausbildung, Beruf, Urlaub und (eigene) Zukunft. Die Zeitformen Präteritum und Perfekt sowie die Partizipien werden hier stärker geübt. Die dänische Grammatik wird

dabei erweitert; mehrere Präpositionen, indirekte Rede, unregelmäßige Substantivformen, Komparativformen von Adjektiven, Wortstellung in Nebensätzen, Passivformen von Verben, bestimmter Artikel usw.

**Intended Learning Outcomes:**

Das Modul orientiert sich an dem Niveau A2 des GER. Die/der Studierende erlangt erweiterte Kenntnisse in der Fremdsprache Dänisch mit allgemeinsprachlicher Orientierung und mit besonderem Gewicht auf das Kommunizieren der eigenen Meinung sowie Gegenstände, Aktivitäten und Medien beschreiben und besprechen. Nach Abschluss dieses Moduls kann sie/er an alltäglicher Konversation aktiv teilnehmen. Die/der Studierende kann seine/ihre Meinung äußern und auf einfache Art beschreiben und diskutieren, bewerten, empfehlen etc.

**Teaching and Learning Methods:**

Kommunikatives und handlungsorientiertes Erarbeiten der Inhalte; gezielte Hör-, Lese-, Schreib- und Sprechübungen; Einzel-Partner- und Gruppenarbeit; Kontrolliertes Revidieren einzelner Aspekte der Grammatik mit vorgegebenen (online-) Materialien; Referieren und Präsentieren nach vorgegebenen Kriterien; moderierte (Rollen-) Diskussionen. Freiwillige Hausaufgaben zur Vor- und Nachbearbeitung festigen das Gelernte.

**Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial

**Reading List:**

Lehrbuch (wird in der LV bekannt gegeben); multimedial gestütztes Lehr- und Lernmaterial

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Dänisch A2 (Seminar, 2 SWS)

Vagner S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ1702: Norwegian A2 | Norwegisch A2

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                             |
|-----------------------------------------|-------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Studien-/Prüfungsleistungen:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht.

Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bestandene Abschlussklausur A1

#### Content:

In diesem Modul werden Grundkenntnisse in der Fremdsprache Norwegisch vermittelt, die es den Studierenden – trotz geringer Sprachkenntnisse – ermöglichen sollen, sich in alltäglichen Grundsituationen zurechtzufinden.

Wir lernen/üben grundlegendes Vokabular und Konversationen und produzieren auch kürzere Texte (z.B. E-Mail, Textzusammenfassung und Kurzpräsentationen); vertiefen und erweitern die Grammatik aus der A1-Stufe und lesen Texte in leicht leserlicher Form.

Grammatische Inhalte: Wiederholung der Pronomen; Komplettierung der Possessivpronomen; komplexer strukturierte Haupt- und Nebensätze mit Modalverben; Imperativ; Präteritum; Perfekt und Plusquamperfekt; Zeitausdrücke-/angaben; Zeit-, Ort- und Richtungsadverbien; Steigerung des Adjektivs.

**Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau A2 des GER. Der/Die Studierende erlangt Grundkenntnisse in Norwegisch mit allgemein sprachlicher Orientierung unter Berücksichtigung kultureller und landeskundlicher Aspekte.

Nach Abschluss dieses Moduls kann der/die Studierende im Gespräch einfache Sätze und Redewendungen zu einem erweiterten Spektrum an vertrauten Themen verstehen und gebrauchen. Dabei handelt es sich um grundlegende Informationen zu alltäglichen Themen unter Einbeziehung landeskundlicher Aspekte. Der/die Studierende ist in der Lage kurze informative Texte oder Mitteilungen zu grundlegenden Situationen zu verfassen und kann längere Texte zu vertrauten Themen verstehen, in denen gängige bzw. einfache alltagsbezogene Sprache verwendet wird und in denen vorhersehbare Informationen zu finden sind.

**Teaching and Learning Methods:**

Kommunikatives und handlungsorientiertes Erarbeiten der Inhalte; gezielte Hör-, Lese-, Schreib- und Sprechübungen; Einzel-Partner- und Gruppenarbeit; Kontrolliertes Revidieren einzelner Aspekte der Grammatik mit vorgegebenen (online-) Materialien; Referieren und Präsentieren nach vorgegebenen Kriterien; moderierte (Rollen-) Diskussionen.

**Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial

**Reading List:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial (wird in der LV bekannt gegeben)

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Norwegisch A2 (Seminar, 2 SWS)

Soevik G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### SZ1703: Norwegian B1 | Norwegisch B1

Version of module description: Gültig ab summerterm 2022

|                                         |                                     |                                  |                                  |
|-----------------------------------------|-------------------------------------|----------------------------------|----------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>Language taught | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>irregularly |
| <b>Credits:*</b><br>3                   | <b>Total Hours:</b><br>90           | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30      |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht.

Hilfsmittel sind erlaubt.

Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.

Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

#### Repeat Examination:

#### (Recommended) Prerequisites:

Bestandene Abschlussklausur A2

#### Content:

In diesem LV werden Kenntnisse der Fremdsprache Norwegisch erarbeitet, die es den Studierenden ermöglichen, sich in vertrauten Situationen und zu Themen von allgemeinem Interesse selbständig in der Zielsprache zu äußern.

Kommunikationsmöglichkeiten (Vokabular, Redewendungen, Dialogmuster etc.) zu den genannten Bereichen, ergänzen das Repertoire an Nebensätzen.

Wir wiederholen / intensivieren und ergänzen elementare Aspekte der Grammatik. Die LV orientiert sich am Niveau B1 des GER. Der/Die Studierende erlangt Kenntnisse in der Fremdsprache

Norwegisch auf standardsprachlichem Niveau unter Berücksichtigung interkultureller, landeskundlicher, und studienbezogener Aspekte.

Nach Abschluss der LV kann der/die Studierende sich in den meisten alltäglichen Situationen, denen man in Studium, Freizeit und auf Reisen im Sprachgebiet begegnet, sicher verständigen, z. B. den eigenen Werdegang vorstellen, Wünsche äußern, Ratschläge erteilen, Anweisungen erteilen, um Erlaubnis bitten, zu alltäglichen Themen eine persönliche Meinung äußern und widersprechen - für und gegen etwas argumentieren, persönliche Erfahrungen und Pläne kommunizieren.

**Intended Learning Outcomes:**

Das Modul orientiert sich am Niveau B1 des GER. Nach Abschluss dieses Moduls kann der/die Studierende wesentliche Inhalte in einfachen Sachtexten, in den Medien und in literarischen Texten verstehen und wiedergeben und sich spontan an Gesprächen zu vertrauten Themen von allgemeinem Interesse beteiligen. Er/Sie kann einfache formelle und längere persönliche Briefe und Texte verfassen, strukturiert zu einem alltäglichen Thema von persönlichem Interesse referieren und schriftlich eine logisch begründete Stellungnahme zu einem aktuellen Thema verfassen, wenn Hilfestellung gegeben wird.

**Teaching and Learning Methods:**

Kommunikatives und handlungsorientiertes Erarbeiten der Inhalte; gezielte Hör-, Lese-, Schreib- und Sprechübungen; Einzel-Partner- und Gruppenarbeit; kontrolliertes Revidieren einzelner Aspekte der Grammatik mit vorgegebenen (online-) Materialien; Referieren und Präsentieren nach vorgegebenen Kriterien; moderierte (Rollen-) Diskussionen. Freiwillige Hausaufgaben zur Vor- und Nachbearbeitung festigen das Gelernte.

**Media:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial

**Reading List:**

Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial (wird in der LV bekannt gegeben)

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Norwegisch B1 (Seminar, 2 SWS)

Soevik G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI000946: Energy Markets I | Energy Markets I

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module entails a written exam at the end of the term (60 minutes). In order to optimally assess the students' achievements, the exam will consist of both, a multiple choice part (20%) and open questions (80%). In the multiple choice part students mainly show that they have professional knowledge regarding the characteristics of energy markets and that are able to classify it. With answering the open questions, students demonstrate their ability to solve problems as well as their ability of abstraction. Mathematical problems will be complemented by questions mainly aiming at economic intuition and thought patterns. Apart from a non-programmable calculator no further tools or documents are permitted (closed book).

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in economics (competition theory), basics in corporate strategy (Porter etc.), ideally industrial economics (market power, oligopoly, barriers to market entry, transparency etc.) and trade (call, put, forward, future etc.)

#### Modules:

- Investment and Financial Management
- Mikroökonomik (Economics I)
- Industrieökonomik (Industrial Economics)
- Introduction to Strategy and Organization

**Content:**

This module gives a broad overview of energy markets and energy industries across all commodities. It covers the whole energy value chain from primary energy supply to energy consumption and presents the most relevant economic concepts.

Focus issues are forecasting energy demand, primary energy exploration and production, supply and demand curves / merit orders in different commodities, specific feature of energy markets, price formation and organised energy trading.

The module will be continued in summer with energy markets 2, focusing on renewables and grid regulation.

**Intended Learning Outcomes:**

After successful participation in the module, students possess a broad basic knowledge regarding the economic specifications of energy markets. Furthermore, students are able to solve energy related problems self-reliantly using both, mathematical techniques as well as attained economic intuition.

Participants are moreover able to transfer economic principles on the special demands of energy markets.

After studying the provided literature, students are able to analyze and assess questions arising in terms of energy policy and recent developments in the fields of energy markets.

Participation in the module leads to a better understanding of energy markets and enables students to develop and evaluate business processes and models in the field of energy economics.

Taking part in the module enables students to competently advocate their views in discussions addressing energy economics and markets.

**Teaching and Learning Methods:**

The module consists of a lecture and an associated exercise course. The lecture provides basic knowledge about economical characteristics of energy markets via presentations. Students are encouraged to study the literature and discuss the provided topics. During the exercise courses, selected examples of problems arising in energy markets are discussed.

**Media:**

Slides and exercises

**Reading List:**

Erdmann, G. / Zweifel, P. (2010) Energy Economics: Theory and Applications; Springer 2017.

Ströbele, W. / Pfaffenberger, W. / Heuterkes, M. (2012) Energiewirtschaft - Einführung in Theorie und Politik; 3. Auflage; Oldenbourg 2012.

Bhattacharyya, S. (2011) Energy Economics - Concepts, Issues, Markets and Governance; Springer 2011.

**Responsible for Module:**

Wozabal, David; Prof. Dr. rer. soc.



**Courses (Type of course, Weekly hours per semester), Instructor:**

Energy Markets I (WI000946) (Vorlesung, 2 SWS)

Ikonnikova S [L], Bieberbach F, Gatscher D

Energy Markets I - Exercise (WI000946) (Übung, 2 SWS)

Ikonnikova S [L], Gatscher D

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001057\_E: Cost Accounting | Cost Accounting

Version of module description: Gültig ab summerterm 2021

|                                  |                             |                                  |                                      |
|----------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6            | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The grading is based on a written exam (60 minutes). Students are allowed to use a non-programmable calculator for the exam. The students answer questions about definitions of cost accounting and about the basic principles of cost accounting. They further answer theoretical questions about concepts of cost accounting and their application. In a second part of the exam they have to apply the concepts to exemplary problems of cost accounting and are asked to perform the methods of cost accounting. Finally, they answer questions about the interpretation of their results.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

None

#### Content:

The course introduces students to managerial cost accounting.

These are:

- cost type accounting (especially the different techniques to register the cost types of material and personnel costs)
- the assignment and allocation of indirect costs to the various cost centers
- the assignment of the determined costs to the individual products by using different techniques of product costing
- calculations of the operating result of the period
- systems of managerial cost accounting (cost planning and cost analysis)
- break even analysis

**Intended Learning Outcomes:**

After having attended this module, students will be able to remember and understand the basic concepts of managerial cost accounting systems. They will be able to analyze accounting problems and identify solutions. They will also be able to explain how managerial cost accounting support decision-making in a company. They will be able to apply the newly acquired knowledge to solve real-world accounting problems. They will be able to compare different concepts of managerial cost accounting such as variable vs absorption costing.

**Teaching and Learning Methods:**

The course consists of a lecture and an exercise. During the lectures the contents are delivered by presentations and discussions. The students are inspired to improve the acquired knowledge by studying the suggested literature. In the exercises the students apply the acquired knowledge in solving problem sets and implementing case studies.

**Media:**

presentations, text books, lecture notes, exercises

**Reading List:**

Friedl, Gunther; Hofmann, Christian; Pedell, Burkhard: Kostenrechnung - Eine entscheidungsorientierte Einführung, 2nd edition, München 2013.

Küpper, Hans-Ulrich; Friedl, Gunther; Hofmann, Christian; Pedell, Burkhard: Übungsbuch zur Kosten- und Erlösrechnung, 6th edition, München 2010.

**Responsible for Module:**

Friedl, Gunther; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Cost Accounting (WI001057, WI001057\_E) (Bachelor TUM-BWL) (Vorlesung, 2 SWS)  
Friedl G [L], Friedl G ( Schoonjans E )

Cost Accounting: Exercise (WI001057, WI001057\_E) (Bachelor TUM-BWL) (Übung, 2 SWS)  
Friedl G [L], Schoonjans E, Schäfer P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001058: Foundations of Entrepreneurial & Ethical Business | Foundations of Entrepreneurial & Ethical Business

Version of module description: Gültig ab summerterm 2021

|                                  |                             |                                  |                                      |
|----------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6            | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The grading is based on a written exam (120 Minutes). The written form of the exam allows a comprehensive assessment of students' knowledge and understanding of the basic principles of entrepreneurship. They will answer questions about the concepts explaining the mindset of entrepreneurial individuals and the management of entrepreneurial firms as introduced in the lecture. They will also answer questions about basic definitions of specific types of entrepreneurship and entrepreneurial behavior. The exams allows for a comprehensive evaluation of students' knowledge of basic principals and models of business ethics and their ability to further develop their knowledge of entrepreneurship. Students will answer questions about basic definitions and theories of ethical behavior and decision making, and they will assess ethical behavior in the business context.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

None

#### Content:

The module introduces students into basic principles of the topic of entrepreneurship from a global and international perspective. Students will be equipped with basic knowledge on:

- definitions, regional aspects, and special forms of entrepreneurship
- entrepreneurial individuals, including their personality, creativity, idea development, cognition, opportunity recognition, decision making, affect, and moving forward from failure
- entrepreneurial firms, including their growth strategies, strategic alliances, and resources.

Beyond that, students will engage in break-out group workshops to personally experience the process of opportunity recognition and development. In these workshops they will work in teams

and apply concepts from academic literature to real-world entrepreneurial problems. Furthermore, students give presentations to the audience and discuss their results.

In addition, the module introduces basic problems, arguments, and theoretical approaches of business ethics. It investigates the chances of realizing moral norms at the intersection of entrepreneurship/economics and ethics. Basic is the analysis of ethical decision processes in corporations and the detailed investigation of situations and alternatives of action. Topics involve reputation, trust and social capital as well as corruption, environmental protection, and global ethical concepts. This part ends with a critical discussion of different research approaches in the debate on business ethics.

### **Intended Learning Outcomes:**

First, students will know and be able to explain basic concepts of entrepreneurship including basic definitions, psychological processes and characteristics of the person of the entrepreneur, and potential development paths of young firms. Further, students will transfer this basic knowledge to real world cases. Thus, students will be able to solve entrepreneurial problems in real world settings drawing on theoretical frameworks of the entrepreneurial process.

Students will be able to understand the ethical meaning of economic theories, reflect on ethical matters in business, and apply ethical theories in entrepreneurship and business settings. Thus, students will be able to decide in ethical manners in entrepreneurial and business life drawing on established ethical theories and concepts.

### **Teaching and Learning Methods:**

The module will combine several learning methods.

- The basic knowledge as well as real world examples will be provided through the lecture.
- Discussions in the lecture and active participation are encouraged and will contribute to deepen the understanding of the concepts introduced.
- Workshops in smaller groups enable the students to apply (part of) their theoretical knowledge to real-world problems. This format additionally fosters creativity and team work.
- Students will get additional background knowledge from the scientific literature in private reading.

The module is also offered at TUM Campus Straubing.

### **Media:**

Presentations, exercises, online materials

### **Reading List:**

Hisrich, R. D., Peters, M. P., & Shepherd, D. A. (2010). Entrepreneurship (8th ed.). New York: McGraw-Hill.

Read, S., Sarasvathy, S., Dew, N., Wiltbank, R. & Ohlsson, A.-V. (2010). Effectual Entrepreneurship. New York: Routledge Chapman & Hall.

Karl Homann/Christoph Lütge: Einführung in die Wirtschaftsethik, 2. Aufl., Münster 2005.

Andrew Crane/Dirk

Matten: Business Ethics: A European Perspective, Oxford 2003.

Karl Homann/Franz Blome-Drees: Wirtschaftsund

Unternehmensethik, Göttingen 1992

**Responsible for Module:**

Patzelt, Holger; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Introduction to Business Ethics (WI001058) (Part II of Module "Foundations of Entrepreneurial and Ethical Business") (Vorlesung, 2 SWS)

Lütge C [L], Lütge C, Poszler F

Introduction to Entrepreneurship (WI001058, WI101058) (Part I of Module "Foundations of Entrepreneurial and Ethical Business") (Vorlesung, 2 SWS)

Patzelt H [L], Baur C, Patzelt H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001072: Corporate Sustainability | Corporate Sustainability [Corp Sust BC]

Version of module description: Gültig ab winterterm 2018/19

|                                  |                             |                                  |                                      |
|----------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6            | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module assessment consists of a written exam (70%) and a written term paper (30%).

By means of a 60-minutes written exam at the end of the term, the aspired learning objectives will be tested. The exam consists of several closed, as well as some open questions. Closed questions were chosen as they allow the lecturer to test whether the students are able to reproduce different corporate sustainability strategies, the sustainability challenges and chances companies are facing and the impact of sustainability issues upon classical business functions. Open questions are the best way to test whether the students are able to make use of the acquired knowledge to answer practical problems by providing own examples. They need to show that they can critically assess current corporate sustainability and business practices.

By writing the term paper, students demonstrate that they are able to observe societal problems faced by corporations or entrepreneurs. They will be able to offer solutions to these problems by elaborating on a business case or a business plan. In this way, students could show their knowledge and ability to tackle ecological and social issues using a business perspective. Overall, students show that they are able to write a term paper within a limited amount of time, using their ability to identify problems and find solution strategies.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

none

#### Content:

The module aims to highlight the most important issues of Corporate Sustainability practice. Challenges of our rapidly changing world such as climate change, peak oil, peak food, pollution etc. call for a paradigm shift in business practice, by acknowledging that a firm's success

cannot be measured by its traditional financial bottom line only, but also by its social/ethical and environmental performance (so-called triple bottom line). Surveys report that an overwhelming majority of executive managers believe sustainability will be critical to their company's future success, but they point to key challenges such as the complexity of implementing sustainable practices across business functions, competing strategic priorities, low consumer interest and willingness to buy/pay, or lack of recognition from the financial markets.

The module will address these challenges, but also show chances arising from corporate sustainability practice. A focus will be put on the integration of sustainability principles across the classical business functions from supply to production, marketing and accounting.

### **Intended Learning Outcomes:**

Upon successful completion of this module, students will be able to (1) understand the sustainability challenges and chances companies face nowadays. They will be able to (2) analyze the impact of sustainability issues upon classical business functions such as supply, production, marketing, finance and accounting. Students will be able to (3) describe corporate sustainability strategies and discuss up-to-date examples of company practice regarding sustainability management. Furthermore students will be able to (4) critically assess current corporate sustainability/business practice. They will be able to (5) collect data and develop strategies related to sustainability challenges in a corporate setting (based on the input presented in class by guest lecturers).

### **Teaching and Learning Methods:**

The module is a seminar. The seminar consists of small lecture units which provide students with the basic theoretical knowledge and of interactive group work. Moreover, conversations give students the opportunity to critically discuss the newly acquired knowledge. As a special feature of the seminar, students will have the opportunity to experience "hands-on" companies placing sustainability at the core of its business strategy. Corporate representatives will share their experience and insights on specific sustainability issues, granting us a glimpse behind the "scenes" of their sustainability management tools and processes.

### **Media:**

Presentations, slides, cases, links and further literature will be provided via [www.moodle.tum.de](http://www.moodle.tum.de)

### **Reading List:**

Orsato, R. (2006):

Sustainability Strategies: When Does it Pay to be Green?

Hart, S. & Milstein, M. (2003):

Creating Sustainable Value. Academy of Management Executive, 2003, Vol. 17, No. 2

Dyllick, T., & Hockerts, K. N. (2002): Beyond the business case for corporate sustainability. Business Strategy and the Environment, 11: 130-141.

Belz, Frank-Martin and Peattie, Ken (2009):



Sustainability Marketing: A Global Perspective,  
Chichester: Wiley, pp. 45-70 (M=Mandatory)

Meadows, D., Randers, J. and Meadows, D. (2004):

Limits of Growth. The 30-Year-Update,

White River Junction, VT: Chelsea Publishing. (M)

Von Weizsäcker, E. U., Lovins, A. B. And Lovins, L.H. (1998):

Factor Four: Doubling Wealth, Halving Resource Use (Introduction) (M)

Dahlsrud, A., (2006): How Corporate Social Responsibility is Defined: an Analysis of 37 Definitions,  
Corporate Social Responsibility and Environmental Management. Wiley InterScience (M)

Tidd, J. and Bessant, J. (2009):

Managing Innovation: Integrating Technological, Market and Organizational Change. John Wiley & Sons Ltd. England.

Tukker, A. (2004):

Eight types of product-service system: Eight ways to sustainability? Experiences from suspronet.  
Business Strategy and the Environment, 13(4), 246-260. (Mandatory reading)

Van Hemel, C.G. (1998):

EcoDesign Empirically Explored, Chapter 2, The Design for Environment Strategy Wheel

#### **Responsible for Module:**

Belz, Frank-Martin; Prof. Dr. oec.

#### **Courses (Type of course, Weekly hours per semester), Instructor:**

Corporate Sustainability (WI001072) (Bachelor TUM-BWL) (Seminar, 4 SWS)

Codita R [L], Belz F, Bendaanane M, Codita R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001122: Introduction to Business Law (MiM) | Introduction to Business Law (MiM) [BusLawMiM]

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The final assessment will be held as a written exam of 120 minutes. The exam consists of two parts which count for approximately 50 per cent each and forming the overall mark.

In the first part of this exam, students will be asked theoretical questions. This will demonstrate to what extent they have memorized and understood principles of the law of contracts, torts, company law, IP and competition law. In the second part, students will also be asked to apply their knowledge to known and fictional cases. This demonstrates if students have developed the required legal analytical skills. Students also need to demonstrate their ability to apply their knowledge to fact settings not discussed in the lecture, and to evaluate the legal consequences.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

None

#### Content:

This module covers the legal essentials of running a business in technology driven markets in Germany and in the European Union. It focuses on typical problems which entrepreneurs and employees might encounter in practice (scenario-based approach). Topics covered will be, inter alia, the formation and termination of contracts, selected types of contract (in particular, sale of goods), torts, property law, the law of business associations, intellectual property law, competition law.

#### Intended Learning Outcomes:

At the end of this module students will be able

- (1.) to name and understand essentials of the legal framework for technology oriented businesses in Germany and in the European Union;
- (2.) to identify and avoid the problems presented by dealing with legal issues in a foreign language (in particular, English as the main business language) and/or in a transnational setting;
- (3.) to grasp and apply the legal principles regulating business activity, in particular regarding liability under tort, contract, company, intellectual property and competition law;
- (4.) to analyse legal implications of typical business situations and to identify their options;
- (5.) to present the results of their analysis in a written analysis.

**Teaching and Learning Methods:**

The lecture will cover the theoretical aspects of the module in a discussion with the lecturer. The exercise will focus on case studies. It will provide the opportunity to work individually or in groups on case scenarios (known and unknown), covering various issues of German and European law. The purpose is to repeat and to intensify the content discussed in the lecture and to review and evaluate legal issues from different areas of law in everyday situations. Students will develop the ability to present these findings in a concise and well-structured written analysis.

**Media:**

Presentations (PPT), Cases

**Reading List:**

Gerhard Robbers, "An Introduction to German Law", 6th edition 2016;  
additional reading material will be made available on the course Moodle site prior to the start of the semester.

**Responsible for Module:**

Maume, Philipp; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Introduction to Business Law (WIHN1122) MIM Heilbronn - Exercise (Übung, 2 SWS)

Haag A

Introduction to Business Law (WI001122): Exercise (Repetition) (MiM) (Übung, 2 SWS)

Haffke L, Primbs M

Introduction to Business Law (WI001122) (MiM) (Vorlesung, 2 SWS)

Maume P

Introduction to Business Law (WIHN1122) MIM Heilbronn - Lecture (Vorlesung, 2 SWS)

Rolsing N

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001125: Energy Markets II | Energy Markets II

Version of module description: Gültig ab summerterm 2016

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is based on a written exam (60 minutes), which has two parts and is open-book. The first part of the written exam ( $\leq 20\%$  of written exam) consists of multiple-choice questions, which tests the students' knowledge and understanding of the basic concepts and economic characteristics of energy markets.

The second part of the written exam ( $\geq 80\%$  of written exam) consists of open questions and calculations. Here students have to show that they can explain how to trade energy commodities in energy markets and interpret the role of energy grids and their regulation. In answering the open questions students demonstrate their ability to analyze business models of utilities and their ability to make business decisions regarding management and investment in the electricity market in response to a changing environment. . Students may use a non-programmable calculator.

Additionally students have the possibility to improve their test score by 10 percentage points through a voluntary midterm assessment. This involves successfully taking part in the browser-based business game offered during the exercise course. The results of the midterm assessment are used only if they improve the overall grade of the written exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in economics (competition) and industrial economics (market power, oligopoly, entrance barriers, transparency).

Modules:

- Energy Markets I
- Economics I (Microeconomics)
- Industrial Economics

**Content:**

In continuation of the lecture "Energy Markets I", students gain an overview of the more fundamental concepts of energy markets (eg. renewable energy promotion schemes, energy trading in wholesale markets). Thereto, the course covers the topics of renewable electricity production, introducing energy trading, a case study of the fracking industry and energy grids/networks. Transmission grid management and expansion are considered as the significant topic of energy grids.

**Intended Learning Outcomes:**

Upon successful completion of this module, students are able to (1) name and (2) summarize the concepts and economic characteristics of all relevant fields of energy markets. Further, they can (3) explain how to trade energy commodities in energy markets. They are able to (4) interpret the role of energy grids and their regulation. Finally, they can (5) apply the aforementioned concepts and theoretical foundations presented in the module. Students are able to (6) analyze business models of utilities and make business decisions regarding management and investment in electricity markets in response to a changing environment.

**Teaching and Learning Methods:**

The module combines various learning methods:

- Basic knowledge, theoretical concepts and practical examples are provided through the lecture.
- Students are encouraged to get additional background knowledge from scientific literature in private reading.
- In the exercise course, students play a browser-based business game. In the course of the business game, the students slip into the role of the Chief Executive Officer of a utility company.

**Media:**

Presentation, white board, exercises, business game

**Reading List:**

Bhattacharyya, S. (2011) Energy Economics – Concepts, Issues, Markets and Governance; Springer 2011.

Erdmann, G. / Zweifel, P. (2010) Energieökonomik – Theorie und Anwendungen; 2. Auflage; Springer 2010.

Ströbele, W. / Pfaffenberger, W. / Heuterkes, M. (2010) Energiewirtschaft – Einführung in Theorie und Politik; 2. Auflage; Oldenbourg 2010.

**Responsible for Module:**

Schwenen, Sebastian; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Energy Markets II (WI001125) (Vorlesung, 2 SWS)

Bieberbach F, Gatscher D, Madadkhani S

Energy Markets II (WI001125) - Exercise (Übung, 2 SWS)

Madadkhani S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001129: Marketing and Innovation Management (MiM) | Marketing and Innovation Management (MiM)

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The grading will be based on a written exam (120 min). By answering multiple choice questions students have to show that they have understood and can apply models and concepts related to markets aspects of innovation and to the organization of the innovation process. The questions also assess whether students can explain and analyze marketing basics (including key terms, theories, frameworks, the use of marketing strategies and marketing mix instruments, and their interrelationship with core concepts in marketing). The questions may require calculations. Students may use a non-programmable calculator to do these calculations.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

none

#### Content:

Market aspects of innovation:

- Innovation: Examples and particularities,
- Innovation and the development of industries,
- Sources of innovation,
- Innovation strategy: Analysis of the market, technology and competition,
- Acquisition of technology: Market, cooperation and networks

Organizing the innovation process:

- The innovation process within the firm,

- R&D, production and marketing,
- Cooperation for innovation?
- Motivation and incentive systems,
- Promoters and champions,
- Roles in the innovation process,
- Opposition against innovation within the firm,
- Integrating customers into the innovation process,
- Measuring and controlling innovation.

**Marketing management:**

- Principles of marketing,
- Marketing strategy and environment,
- Creating customer value, satisfaction, and loyalty,
- Information management and market research,
- Analyzing consumer and business markets,
- Competition and differentiation from competitors,
- Segmenting, targeting, and positioning,
- Creating and managing products and services, brand management,
- Pricing,
- Marketing communications, marketing channels, and service P's.

**Intended Learning Outcomes:**

At the end of the module, students will be able to (1) recognize and apply models and concepts related to the market aspects of innovation (e.g., modes of acquisition of technology) and to the organization of the innovation process (e.g., promoters and champions in the innovation process), (2) identify how they can be concretely used in companies, (3) evaluate which models and concepts are most useful in a given situation, (4) remember and understand the key terms used in marketing (e.g., customer lifetime value, segmenting, targeting, and positioning, marketing mix instruments), (5) explain common marketing theories and frameworks (e.g., service-dominant logic, decision-making styles), (6) describe and justify the use of both marketing strategies and marketing mix instruments, and (7) relate the strategies and use of instruments to core concepts in marketing, such as customer-perceived value, satisfaction, and loyalty, and (8) evaluate existing innovation and marketing concepts in terms of their strengths and weaknesses in theory and practice.

**Teaching and Learning Methods:**

The module consists of two lecture series, each of which include two sessions held by guest speakers to refer to state of the art examples of marketing and innovation. Students will be asked to read the literature before the lecture and prepare for each lecture using texts and slides that are provided. Students will be enabled to relate the material to decision making in practice, by means of examples and cases. In a group project, students can elect to apply key innovation concepts and develop their own case examples, which will subsequently be shared in a wiki format. Students will also be encouraged to discuss the material in online forums that are provided to the students between lectures.



**Media:**

Lecture slides are available via Moodle. Presentation slides, online discussion forum

**Reading List:**

- Afuah - Innovation Management. strategies, implementation, and profits
- Dodgson, Gann, Salter - The Management of Technological Innovation (Chapter 4)
- Teece - Profiting from Technological Innovation: Implications for integration, collaboration, licensing and public policy
- Stamm - Structured Processes for Developing New Products
- Hauschildt, Kirchmann - Teamwork for innovation - the "troika" of promoters
- Kotler/Keller/Brady/Goldman/Hansen (2012): Marketing Management, 2nd European ed., Pearson: Harlow.
- Kotler/Armstrong (2014): Principles of Marketing, 15th ed., Pearson: Harlow.
- Homburg (2015): Marketingmanagement. Strategie - Instrumente - Umsetzung - Unternehmensführung, 5. Aufl., Gabler: Wiesbaden.

**Responsible for Module:**

Henkel, Joachim; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Technology and Innovation Management: Introduction (WI001129) (MiM) (Vorlesung, 2 SWS)  
Latifi G

Marketing (WI001129) (Vorlesung, 2 SWS)

Schnurr B, Ungemach C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001131: Production and Logistics (MiM) | Production and Logistics (MiM)

Version of module description: Gültig ab summerterm 2021

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment takes place in form of a written exam (120 min) at the end of the semester. In the exam students demonstrate that they are able to explain, discuss and critically evaluate various concepts of production management and logistics. Furthermore, they proof that they can apply the discussed quantitative approaches for operations and supply chain management, critically evaluate them and discuss the results. The answers involve own formulations, as well as calculations or mathematical modelling.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

none

#### Content:

This is an introductory module, providing an overview on planning problems in (1) production and (2) logistics and on methods to solve these.

(1) In the production part, students become acquainted with different planning hierarchies (strategic, tactical and operational) and the planning problems on the respective level:

- At the beginning, strategic planning problems such as site location planning are covered.
- Then, in the tactical planning level, we discuss questions concerning the infrastructure of production systems.
- In the second part of the lecture, operational planning decisions are treated.
- We introduce demand forecasting techniques and examine master planning problems.
- After giving attention to material requirements planning, we proceed to production planning issues where we focus on lot sizing questions, machine scheduling and sequencing in flow lines.

(2) The logistics part of the module discusses questions along the supply chain:

- Beginning with transport logistics and the corresponding planning problems on the determination of tours, routes and packing schemes.
- Afterwards, within the area of material logistics, inventory control policies and their extension to the stochastic case are elaborated.
- The strategic design of the logistics network is dealt with when talking about planning problems of supply chain management.
- Then, the interfaces to the predecessor resp. successor companies in the supply chain are explained. Within the procurement stage, methods for the selection of suppliers and within the distribution stage, the installment of a suitable distribution network and the processes in the warehouse are discussed.

In order to deal with the arising decision problems in production and logistics, simple heuristics as well as simple linear programming and mixed integer programming models are discussed and applied.

### **Intended Learning Outcomes:**

At the end of the module the students will be able to:

- understand the relation between different planning problems in production and logistics
- analyze specific planning problems on the strategic, tactical and operational level in detail. Apply respective solution methods approaches. Understand how these solution methods are derived and motivated.
- understand the main problem settings in production and logistics planning and explain resulting strategic decision making and managerial tasks
- identify, quantify and evaluate the main economic trade-offs in decision making in production and logistics (e.g. holding vs. setup costs, costs vs. service) and their implication on supply chain performance.
- select and apply the solution approaches taught in this course to specific industry problem settings in production and logistics. Understand how the problem structure dictates the ideal solution framework.
- critically evaluate the theoretical frameworks and their potential applications
- analyze novel solution approaches for cross-disciplinary issues from industry

### **Teaching and Learning Methods:**

The lecture 'Production Management' will take place in form of a flipped classroom. The students will prepare the announced topic using the lecture material and the learning videos provided. During the classes, questions regarding the topic will be discussed and selected exercises are used to gain a deeper understanding of the prepared topic.

The lecture 'Logistics und Supply Chain Management' is a recorded class room lecture (Lecturio) and supported by tutorials. Students are expected to study the supplementary reading material and use the video recordings of the lecture to gain a comprehensive understanding of the course content.

**Media:**

Presentations, Script (Production and Supply Chain Management), Recordings of lecture (Supply Chain Management)

**Reading List:**

Günther, H.O., Tempelmeier, H. (2012), Produktion und Logistik, 9. Auflage, Springer  
Ghani, G., Laporte, G., Musmanno R. (2013), Introduction to Logistics Systems Management, 2. Aufl., Wiley

**Responsible for Module:**

Grunow, Martin; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Production Management (WI001131) (MiM) (Vorlesung, 2 SWS)  
Grunow M [L], Grunow M, Greil T

Logistics and Supply Chain Management (WI001131) (MiM) (Vorlesung, 2 SWS)  
Minner S ( Bloemer A )

Production and Logistics MIM Heilbronn (WIHN1131) (Vorlesung, 4 SWS)  
Mohadikar M, Sriraman S, Wuttke D  
For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001138: Investment and Financial Management (MiM) | Investment and Financial Management (MiM) [laF]

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The grading is based on a written exam with a duration of 120 minutes. To test whether the students acquired the theoretical basics in financial analysis and investment planning, multiple choice questions are asked, where they have to find the correct or incorrect statement among several alternative statements. By using a calculator and the formulary issued by the chair, the students for example have to analyze investment projects, create the optimal capital structure of projects or firms, evaluate bonds, stocks, or equity options to demonstrate their ability to apply financial tools based on finance theory and to critically analyze different problem sets which finally results in a context-based conclusion.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

None

#### Content:

The module will give students a broad understanding of the instruments to analyse and evaluate investment opportunities. Subsequent, a complete list of these methods:

- Financial Statement Analysis (balance sheet analysis, analysis of profit and loss account)
- Investment Analysis (net present value method, actuarial return)
- Capital Budgeting (determination of free cashflows, choosing between alternatives)
- Cost of Capital (equity costs, borrowing costs, capital costs)
- Capital Structure

**Intended Learning Outcomes:**

Upon completion of this module students will be able to name and apply important measures of company performance indicators, create an optimal capital structure for companies and investment projects in a world without taxes (Modigliani-Miller) and with taxes (valuing the tax shield), which ultimately enables them to analyse and evaluate investment opportunities. Finally, students will be able to understand and analyse companies' investment decision making process and to create investment as well as capital budget plans. Furthermore, students will be able to remember and understand key theories of corporate finance and to apply fundamental methods of corporate finance which sets the fundamental basis for the overall module.

**Teaching and Learning Methods:**

The module will combine several learning methods.

- Weekly Lecture: Presentation of theoretical basics and applied examples, supported by slides. As a better learning effect is reached by a dynamic learning environment, the student can join in live surveys with onlineTED.
- Exercise available on several dates: Calculation of selected exercises from the set of exercises in small groups so the students can directly ask questions about the calculations.
- Set of exercises with applied examples for individual practising of exercises.

**Media:**

Presentations, exercises with solutions, onlineTED

**Reading List:**

Berk/DeMarzo, Corporate Finance, 3rd. Edition, Pearson.

**Responsible for Module:**

Loos, Benjamin; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Investment & Financial Management (WI001138) (MiM) (Vorlesung, 2 SWS)

Braun R ( Nardini M )

Investment & Financial Management (WI001138): Exercise (MiM) (Übung, 2 SWS)

Braun R [L], Nardini M

Investment and Financial Management (WIHN1138) MiM Heilbronn - Vorlesung (Vorlesung, 2 SWS)

Müller S

Investment and Financial Management (WIHN1138) MiM Heilbronn - Exercise (Übung, 2 SWS)

Müller S [L], Gong Z, Preissler F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001172: Core Topic: Politics & Governance | Core Topic: Politics & Governance

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The grading is based on three exercises spread throughout the term. In these exercises students demonstrate their ability to understand and apply basic concepts, case studies and analytic tools from the fields of STS and Public Policy, and to systematically analyze complex problems using these concepts, case studies and tools, particularly with regard to current questions and policy debates.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

This module is offered as part of the core curriculum of the MCTS Master's programs and builds on knowledge that students from these M.A. programs have obtained in the winter term. However, it is also explicitly open to graduate students with other backgrounds who are interested in Science and Technology (S&T) Policy and wish to engage with questions of how S&T shape, and are being shaped by, politics and society. Interested students who are not part of the MCTS Master's programs must consult with the instructor in order to be admitted to the respective course.

#### Content:

Students are provided with a graduate-level introduction to the key questions and issues facing societies at the increasingly important intersection between science, technology, and public policy. Students explore how science and technology (S&T) enter the policy process (and vice versa), how changes in S&T pose questions that require political and public attention, and how S&T are being governed through political institutions. Among the range of topics covered are:

- What is the 'right' relationship between science, technology, and politics? What models exist? How does (scientific) 'truth' interact with (political) 'power'?
- How do different sources of public authority and legitimacy - politics, expertise, the law, and the market - relate to one another in the context of S&T? What conflicts exist among them?
- How is political decision-making possible in light of scientific controversies and irreducible risks?
- How do organizations at the interface between science and politics work?
- What is the role of 'the public' in S&T policy?
- Why do societies fund science? How do they govern it?
- Do technologies have inherent political or ethical properties?
- How do we envision the world through S&T? How do these visions relate to national political cultures?
- How do societies cope with unavoidable technological risk, failures, and disasters?
- How much should we rely on models? What is the role of models in the policy process?

Over the course of the semester, students acquire knowledge on a range of concepts and analytic lenses from the fields of Science and Technology Studies (STS) and Public Policy that help them deal with complex questions surrounding the politics of science and technology, identify fundamental patterns and recurring tensions in S&T policy, and speak about them with confidence in the context of their own research. In particular, students are encouraged to take and defend a normative position on the questions and cases they encounter during the class. Case studies draw upon a range of S&T sub-domains, including climate change, environmental regulation, nuclear power, biotechnology, AIDS activism, military technology, geoengineering, and space.

One of the central themes of the module and the starting point for discussions is the idea of a 'rational' policy process - i.e. finding 'optimal' solutions for well-defined problems using unambiguous scientific evidence, and implementing these solutions with the precision of a 'social engineer' - which is contrasted with the ideal, an open, deliberative political process that accommodates a plurality of values, opinions, and life choices. This fundamental tension of technocratic vs. deliberative politics is traced throughout a wide range of S&T policy problems and sites.

### **Intended Learning Outcomes:**

On completion of this module students

- understand and are able to apply basic concepts and analytic tools from the fields of STS and Public Policy (e.g. deliberative vs. technocratic policy approaches, expertise and other sources of legitimacy in decision-making, scientific controversies, boundary work)
- can systematically analyze complex problems using these concepts and tools, particularly with regard to current questions and policy debates at the interface of science, technology, society, and public policy (e.g. trade-offs between competing values in science policy, public engagement in scientific and technological controversies, governing scientific input into science policy decision-making, technology design ethics, responsible research and innovation)
- have knowledge of a range of classical STS and Policy case studies and are able to draw parallels to current events and discussions (e.g. nuclear power, TTIP, biotechnology, infrastructure development)



- have basic knowledge of current research topics and methods in STS and Public Policy

**Teaching and Learning Methods:**

This module follows a hybrid seminar-lecture format in which students receive lecture-style input to obtain a systematic overview of specific topics and issues, and engage in extensive in-class discussions with their peers to learn how to reflect and position themselves with regard to these issues and to systematically analyze complex problems. Lectures and discussions are based on assigned readings, which are provided to students in a course description at the beginning of the term. A key part of the instruction is hence based on the close reading of assigned texts and case studies, and the reflection/interpretation of the arguments contained therein. Moreover, the module uses regular exercises to assess learning progress and practice the application of course content to real-life cases.

**Media:**

Reader (literature provided in course moodle), slidepresentations; flipcharts; video clips; newspaper articles and blogs

**Reading List:**

- Hal K. Colebatch (2009). Policy. 3rd Edition. Berkshire, England: Open University Press. Chapter 2 ('What's the Idea?'), pp. 7-22; Chapter 4 ('What is it for?'), pp. 42-54.
- Deborah Stone (2012). Policy Paradox: The Art of Political Decision Making. 3rd Edition. New York, NY: W. W. Norton & Company. Preface, Chapters 1-3 ('The Market and the Polis,' 'Equity,' 'Efficiency'), Chapter 5 ('Liberty').
- Alvin M. Weinberg (1972). 'Science and Trans-Science.' Minerva, 10(2), pp. 209-222
- Daniel Sarewitz (1996), Frontiers of Illusion. Philadelphia: Temple University Press. Ch. 5 ('The Myth of Authoritativeness'), pp. 71-96.
- Sheila Jasanoff (2005). 'Law's knowledge: Science for justice in legal settings.' American Journal of Public Health, 95(1), pp. 49-58.

Plus additional literature specified at the beginning of the course

**Responsible for Module:**

Pfotenhauer, Sebastian; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Introduction to Science & Technology Policy (WI001124, WI001172) (Seminar, 4 SWS)

Pfotenhauer S ( Wentland A ), Sardo S, Wentland A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001185: Entrepreneurial, Strategic, and International Management | Entrepreneurial, Strategic, and International Management

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The grading of the module is based on a written exam (120 Minutes). First, the written form of the exam allows a comprehensive assessment of students' knowledge and understanding of the basic principles of entrepreneurship. They will answer questions about the concepts explaining the mindset of entrepreneurial individuals and the management of entrepreneurial firms as introduced in the lecture. They will also answer questions about basic definitions of specific types of entrepreneurship and entrepreneurial behavior. Second, the written exam requires students to show their ability to reproduce fundamental knowledge about strategic and international management by answering questions about theories, models and methods related to management as well as strategies of multinational enterprises. The exam also assesses students' ability to understand the fundamentals of strategic and international management as well as to identify and analyze challenges and problems of multinational firms because they will answer questions related to management concepts, stakeholder management, finance, market entry of firms etc. The written exam will include single choice questions. Resources such as books, course slides, personal notes, etc. are not allowed to answer the questions.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

#### Content:

Entrepreneurship provides students with knowledge of the theoretical concepts and models of entrepreneurship. The set up of this first part is twofold:

(1) Students will acquire in-depth theoretical knowledge on:

- Definitions, regional aspects, and special forms of entrepreneurship in a complex and uncertain environment

- Entrepreneurial individuals, including their personality, creativity, idea development, cognition, opportunity recognition, decision making, and affect

- Entrepreneurial firms, including their growth strategies, strategic alliances, and resources.

(2) Beyond that, students will engage in break out group workshops to personally experience the process of opportunity recognition and development. In these workshops they will work in teams and apply theoretical models from academic literature to real world entrepreneurial problems.

Furthermore, students give presentations to the audience and discuss their results.

Strategic and international management targets long term decisions and the sustainable development of the company. In the course of globalization, it is crucial to consider the international dimension of management. Strategic and international management skills are not only important in the management of companies that are doing business across borders, but also within single business functions when shaping competitive strategy. In detail, this module discusses the following aspects:

- Foundations of management
- Stakeholders, objectives, and governance
- Strategic decision making and performance
- Strategy analysis
- Competitive strategies
- Strategy implementation

### **Intended Learning Outcomes:**

First, students will know and be able to explain basic concepts of entrepreneurship including basic definitions, psychological processes and characteristics of the person of the entrepreneur, and potential development paths of young firms. Second, students will transfer this basic knowledge to real world cases. Thus, students will be able to solve entrepreneurial problems in real world settings drawing on theoretical frameworks of the entrepreneurial process. Third, upon successful completion of this module, students are able to understand and reproduce fundamental knowledge about the management of multinational enterprises. Fourth students are able to explain and apply theories, models and methods related to international management as well as strategies of multinational enterprises. Finally, students are able to identify and analyze challenges and problems in multinational enterprises respectively; they are able to develop and outline solution approaches by applying theoretical concepts.

### **Teaching and Learning Methods:**

The module will combine several learning methods.

- The basic knowledge as well as real world examples will be provided through lectures. Lectures will be done in class as well as in form of online lectures and interactive in-class lectures and online feedback sessions.

- During the lectures relevant concepts, approaches, theories, and empirical studies in the fields of entrepreneurship, strategic and international management are introduced and discussed.

- Discussions in the lecture and active participation are encouraged and will contribute to deepen the understanding of the concepts, theories and methods introduced as well as application to practical examples and case studies.
- Students will get additional background knowledge from the academic literature in private reading. The self-study of literature is part of the whole module.
- Moreover, students are encouraged to engage in individual exercises and small group assignments in order to look deeper into the course contents.

**Media:**

Presentations, exercises, case studies, online materials, Online video material (download)  
Digitally retrievable script (download)  
International academic literature (English)

**Reading List:**

Entrepreneurship:

Hisrich, R. D., Peters, M. P., & Shepherd, D. A. (2010). Entrepreneurship (8th ed.). New York: McGraw-Hill.

Read, S., Sarasvathy, S., Dew, N., Wiltbank, R. & Ohlsson, A.-V. (2010). Effectual Entrepreneurship. New York: Routledge Chapman & Hall.

Strategic and International Management:

Cyert, R.M., March, J.G. (1963). A Behavioral Theory of the Firm. Englewood Cliffs: Prentice-Hall. Chapter 3 "Organizational Goals".

Drucker, P. M., (1954). The practice of management. New York: Harper. Chapter 1-3.

Freeman, R.E. (1994). Strategic Management: A Stakeholder Approach. Cambridge: Cambridge University Press, Chapter 1 "The stakeholder approach".

Hambrick, D.C. & Fredrickson, J.W. (2005). Are you sure you have a strategy? Academy of Management Executive, 19(4), 51-62.

Johnson, G., Whittington, R., Scholes, K. (2014). Exploring Strategy. Text and Cases. Harlow: Pearson. Chapter 13, 430-461.

Noorderhaven, N. (1995). Strategic decision making. Addison-Wesley: 162-174.

Peng, M., Meyer, K., (2011). International Business. London: Cengage Learning. Chapter 1 and Chapter 12, 359-387.

Porter, M. (1996) What is Strategy? Harvard Business Review, No. 6, 61-78.

Rothaermel, F.T. (2013). Strategic Management, New York: Mc Graw-Hill. Chapter 1.

Van Horne, J.C., Wachowicz, J.M. (2008). Fundamentals of Financial Management, Edinburgh Gate: Pearson Education Limited, 13th edition. Chapter 1, 6, 15.

**Responsible for Module:**

Breugst, Nicola; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Entrepreneurship (WIHN1185) (MiM Campus Heilbronn) (Vorlesung, 2 SWS)

Bird M, von Nitzsch J

Entrepreneurship (WI000984, WI900005, WI001185) (Vorlesung, 2 SWS)  
Breugst N ( Stratz L )

Strategic International Management (WIHN1185) (MIM Campus Heilbronn) (Vorlesung, 2 SWS)  
Dlouhy K

Strategic and International Management (WI001114, WI900012, WI001185) (Master) (Vorlesung, 2 SWS)  
Hutzschenreuter T [L], Hutzschenreuter T  
For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001204: Economics of Water Use, Regulation and Markets | Economics of Water Use, Regulation and Markets

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In a written examination at the end of the semester of 120 mins (in class), students will demonstrate the ability to understand and analyze concepts and methodological approaches related to water resource management using economic terminology, and the ability to apply mathematical tools to solve specific calculus problems. A written exam is necessary in order to assess the holistic understanding and analytical competencies of the students. Students will have to option to give an in-class presentation (~15 min) of a paper related to water resource economics that they will choose from a list of references provided by the instructor. The in-class presentation (mid-term assignment) is optional and improves the final grade by 0,3. The extra credit from the in-class presentation cannot be transferred in the case of re-examination.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Students taking this course should be familiar with the basics of microeconomics as well as mathematical economics (derivatives, basic function integrals and graphs). However, all necessary concepts will be introduced before application.

#### Content:

The course will examine the incentives that lead to overexploitation of water recourses and how altering these incentives can promote socially optimal use patterns. The course will also provide the students with a set of analytical tools that can be used to work on water issues or natural resource issues more broadly.

Those topics are:

1. Introduction and Economics Basics
2. Agricultural Water Use

(water rights, agricultural water use efficiency and productivity, land allocation, technology choice, environmental quality)

3. Residential Water Use

4. Water, Land Use and Environmental Aspects of Biofuel Production

5. Other Approaches to Value Water

(hedonic modelling, experimental economics, nonmarket valuation approach)

6. Intertemporal and Interregional Aspects of Water

7. Water Markets Around the World

(Europe, China, USA)

### **Intended Learning Outcomes:**

This course is designed to introduce students to the subject of water economics.

Upon successful completion of the module, students will be able to:

- understand the basic concepts and economic models used to study the economics of water resources issues.
- select and apply the appropriate economic model to solve water policy problems as for example producer's profit or consumer's utility maximization.
- provide economic intuition for mathematical answers to water management problems.
- apply models to address a wide range of water resource problems and assess the economic effects of decision making process at different levels based either on the water demand or the water supply side of the economy.
- critique journal articles pertaining to economics of water resources.

### **Teaching and Learning Methods:**

Theoretical concepts and example exercises will be given by the lecturer on the blackboard and by PowerPoint presentations to build the required knowledge base in water resource economics. Q&A sessions at the beginning of each lecture will be provided to recapitulate the previous lecture. In addition, under the supervision and help of the lecturer, in-class application exercises will be used to create real-world water management problems for which students in randomly assigned groups will create and solve problems. Discussion of relevant scholarly articles and literature will be used to aid understanding of the topic covered.

### **Media:**

Presentation slides, Blackboard, hand-outs, Moodle course to provide materials (pdf of papers to read)

### **Reading List:**

Auffhammer, M. et al., "The Value of Supply Reliability in Urban Water Systems," Journal of the Association of Environmental and Resource Economists, Working paper.

Caswell, M. & D. Zilberman, "The Effects of Well Depth and Land Quality on the Choice of Irrigation Technology," American Journal of Agricultural Economics 68(1986): 798-811.

Chong, H. & D. Sunding, "Water Markets and Trading," Annual Review of Environment and Resources 31(2006): 239-264.

Gisser, M., "Groundwater: Focusing on the Real Issue," Journal of Political Economy 91(1983): 1004-1027.

Green, G. et al., "Explaining Irrigation Technology Choices: A Microparameter Approach," American Journal of Agricultural Economics 78(1996): 1064-1072.

Renwick, M. & R. Green, "Do Residential Demand Side Policies Measure Up? An Analysis of Eight California Water Agencies," Journal of Environmental Economics and Management 40(2000): 37-55.

Zilberman, D. et al., "Changes in Water Allocation Mechanisms for California Agriculture," Contemporary Economic Policy 12(1994): 122-133.

The list will be expanded and updated using material from a variety of textbooks and journal papers corresponding to each of the topics.

**Responsible for Module:**

Prof. Dr. Johannes Sauer Jo.sauer@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Economics of Water Use, Regulation and Markets (WI001204) (Vorlesung, 4 SWS)

Sauer J [L], Vracholi M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### WI001223: Challenges in Energy Markets | Challenges in Energy Markets

*Global power plant projects in a changing energy market*

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is based on a written exam (60 minutes), which has two parts. The first part ( $\leq 20\%$ ) consists of multiple-choice questions, which test the students' understanding and basic knowledge of global energy markets, energy projects and manufacturers of energy technologies. The second part ( $\geq 80\%$ ) consists of open questions, where students have to show their ability to analyze and evaluate global energy projects, current developments and the challenges for manufacturers of energy technologies, including the successful execution of large-scale power plant projects. Students moreover have to apply their ability to compare various financing models for different power plant types. Further, they have to apply theoretical concepts presented in the lecture.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

None

#### Content:

In the course of this module, students gain an overview of global power plant projects in a changing energy market. The module covers the following topics: general expectations for the energy market up to 2030; mix of power generation technologies; execution of energy projects into themes of project management; case studies for individual stages of project execution, challenges and project risks; financing models of energy projects; supply chain management - exemplified by various power plant technologies; methods to implement innovation.

**Intended Learning Outcomes:**

After completion, students are able to analyze the fundamental changes taking place in the worldwide energy markets, the specific challenges, and the competitive environment. Further, they are able to outline how large-scale power plant projects are planned and successfully executed. They can also compare various financing models for the different types of power plants. Furthermore, they can analyze the importance of supply chain management for manufactures of various power technologies. Moreover, they can differentiate between various methods for implementing innovations. Finally, they are able to apply theoretical concepts to energy markets and manufacturers of energy technologies.

**Teaching and Learning Methods:**

The module is delivered through lecture and combines various learning methods:

- Basic knowledge, theoretical concepts and practical examples regarding energy markets are provided through the lecture.
- Controversial discussions and active participation in class are encouraged to deepen understanding of the contents presented.

**Media:**

Presentation, Exercises

**Reading List:**

- Burger, M.; Graeber, B.; Schindlmayr, G.: Managing Energy Risk: An Integrated View on Power and Other Energy Markets. John Wiley & Sons, 1st Edition, 2007.
- Erdmann, G.; Zweifel, P.: Energieökonomik – Theorie und Anwendungen. Springer, 2. Auflage, 2010.
- International Energy Agency, World Energy Outlook
- Konstantin, P.: Praxisbuch Energiewirtschaft. Energieumwandlung, -transport und -beschaffung im liberalisierten Markt. Springer, 2. Auflage, 2009.
- Schiffer, H.-W.: Energiemarkt Deutschland. TÜV-Media, 11. Auflage, 2010.
- Yergin, D.: The Quest-Energy, Security, and the Remaking of the Modern World, 2012.

**Responsible for Module:**

Schwenen, Sebastian; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Challenges in Energy Markets (WI001223) (Vorlesung, 2 SWS)

Schwenen S [L], Birnbaum L, Gorski V, Kiszka A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ1082: Fish Biology and Aquaculture | Fischbiologie und Aquakultur

Version of module description: Gültig ab winterterm 2015/16

|                                         |                            |                                  |                                      |
|-----------------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Bachelor/Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5                   | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>82   | <b>Contact Hours:</b><br>68          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Das Modul wird mit einer 30-minütigen mündlichen oder einer 90-minütigen schriftlichen Prüfung abgeschlossen. Die Art der Prüfung hängt von der Teilnehmerzahl am Modul ab und wird vom Dozenten zu Semesterbeginn bekannt gegeben.

Die Klausurnote bildet die Gesamtnote des Moduls und erstreckt sich über alle Bereiche der Vorlesungen und der Übung. In der Klausur wird von den Studierenden nachgewiesen, dass sie in der Lage sind unterschiedliche theoretische Grundlagen der Fischbiologie und der Aquakultur ohne Hilfsmittel abzurufen. Sie beantworten Verständnisfragen zu den in der Vorlesung behandelten Themenfeldern und geben zugrundeliegende Definitionen wider. Das Beantworten der Fragen erfordert eigene Formulierungen. Wird die Modulleistung in Form einer mündlichen Prüfung erbracht, soll in dieser nachgewiesen werden, dass die Studierenden funktionelle Zusammenhänge verstanden haben und die Anwendungen in der Gewässernutzung und Aquakultur veranschaulichen können. Die Gesamtnote setzt sich 1:1 aus den Prüfungsteilen Fischbiologie und Aquakultur zusammen.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Grundlagen in Zoologie und Ökologie; Thematisches Interesse

#### Content:

a) Fischbiologie: Grundlagen der Fischbiologie (Evolution, Systematik, Anatomie, Physiologie, Ernährung); wissenschaftliche Methoden der Fischbiologie (z.B. Altersbestimmung, Elektrofischerei); Gewässerökologie und Aquatische Biodiversität; Einfluss der Fischerei und Gewässernutzung auf aquatische Ökosysteme

b) Aquakultur: Einführung in wirtschaftlich bedeutende Arten der Aquakultur; Grundlagen der Ernährungsphysiologie und Fischhaltung; Produktionssysteme (Schwerpunkt Salmoniden und Cypriniden); Beispiele der internationalen Aquakultur; Produktqualität; Ökologische Bewertung

### **Intended Learning Outcomes:**

Nach der erfolgreichen Teilnahme am Modul kennen die die theoretischen Grundlagen der Fischbiologie und Aquakultur und sind in der Lage:

- wissenschaftliche Methoden der Fischbiologie zu beschreiben
- Gewässernutzung nach fischökologischen Aspekten zu verstehen und zu diskutieren
- wichtige Aquakultur-Produktionssysteme zu beschreiben
- Aquakultur-Produktionssysteme nach tierphysiologischen, qualitativen, ökonomischen und ökologischen Aspekten zu klassifizieren

### **Teaching and Learning Methods:**

Das Modul setzt sich aus der Vorlesung Fischbiologie und der darin enthaltenen Übung sowie der Vorlesung Aquakultur zusammen.

Die theoretischen Grundlagen werden in der Vorlesung mittels Präsentationen und Vorträgen vermittelt. Zusätzlich gibt es eine in der Vorlesung enthaltene Übungsveranstaltung, in der Grundlagen zur Fischanatomie, Fischreproduktion und Gewässerbiologie anhand von ausgewählten Beispielen demonstriert und von den Studierenden praktisch geübt werden. Literaturhinweise erleichtern den Einstieg in die Nachbereitung und Vertiefung des Lernstoffs.

### **Media:**

Power-Point Präsentation, Tafel, Flip-chart, Handzettel, Fallbeispiele, praktische Übungen / Demonstrationen

### **Reading List:**

P.B. Moyle & J.J. Cech: An introduction to ichthyology; Benjamin-Cummings Publishing, 2003; W. Schäperclaus & M. von Lukowicz: Lehrbuch der Teichwirtschaft; Parey Verlag; 1998; G.S. Helfman: Fish Conservation: A Guide to Understanding and Restoring Global Aquatic Biodiversity and Fishery Resources; Island Press; 2007; C.D. Webster & C.E. Lim: Nutrition requirements and feeding of finfish for aquaculture; CABI Publishing; 2002

### **Responsible for Module:**

Geist, Jürgen; Prof. Dr. rer. nat.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Fischbiologie (Vorlesung, 2 SWS)

Geist J

Fischbiologische Übung (Übung, ,533 SWS)

Geist J [L], Geist J

Aquakultur (Vorlesung, 2 SWS)

Geist J, Wedekind H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ1171: Climate change related challenges in sewage treatment biology and engineering ecology | Klimabedingte Herausforderungen für Abwasserbiologie und Ingenieurökologie

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung erfolgt in Form einer 60-minütigen schriftlichen Prüfung. Anhand der Prüfung zeigen die Studierenden, dass sie zentrale Faktoren und Prozesse des Gewässerschutzes verstehen, die Ingenieurökologie im Hinblick auf biologische Abwasserreinigung und deren Zusammenhänge mit der Gefährdung aquatischer Biodiversität verstehen, biologische und naturnahe Abwasserreinigungssystemen bewerten können, wichtige Analysemethoden in der Abwasserreinigung verstehen sowie den Einfluss des Klimawandels und Anpassungsmaßnahmen verstehen.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Thematisches Interesse; Grundkenntnisse der biologischen Abwasserreinigung wären hilfreich, das Belegen anderer Lehrveranstaltungen aus dem Bereich der Aquatischen Ökologie wird empfohlen

#### Content:

Das Modul umfasst folgende Inhalte:

- Grundlagen des Gewässerschutzes (Gesetzgebung, Wasserrahmenrichtlinie, Geschichte und Entwicklung der biologischen Abwasserreinigung, Hygiene),
- Grundlagen Klimawandel (Klimapolitik in Bayern, EU, global, Klimaanpassungsforschung, Mitigation und Adaptation),
- Biologie der Abwasserreinigung (Mikroskopisches Bild, Nährstoffkreisläufe),

- Ingenieurökologie (Verfahren der technischen Abwasserreinigung, Abhilfemaßnahmen bei Betriebsstörungen anhand biologischer Indikatoren, Verfahren der naturnahen Abwasserreinigung, innovative Verfahren, wie Hygienisierung, Bioakkumulation, Biofiltration, Membranbelebung),
- Strategien und Methoden zum Schutz aquatischer Ökosysteme in Kläranlagen (Nährstoffe, Arzneimittelreste);
- Analytik und Untersuchungsmethoden bei der biologischen Abwasserreinigung

### **Intended Learning Outcomes:**

Nach erfolgreichem Abschluss dieses Moduls sind die Studierenden in der Lage,

- zentrale Faktoren und Prozesse des Gewässerschutzes zu verstehen;
- Ingenieurökologie im Hinblick auf biologische Abwasserreinigung und deren Zusammenhänge mit der Gefährdung aquatischer Biodiversität zu verstehen;
- biologische und naturnahe Abwasserreinigungssystemen zu bewerten;
- nachhaltige Schutzkonzepte für Gewässer zu entwickeln und zu bewerten;
- wichtige Analysemethoden in der Abwasserreinigung zu verstehen;
- den Einfluss des Klimawandels und Anpassungsmaßnahmen zu verstehen.

### **Teaching and Learning Methods:**

Das Modul besteht aus einer Vorlesung, einem Seminar und zwei Tagesexkursionen.

In der Vorlesung werden die zentralen Faktoren und Prozesse des Gewässerschutzes, die Ingenieurökologie im Hinblick auf biologische Abwasserreinigung und deren Zusammenhänge mit der Gefährdung aquatischer Biodiversität sowie der Einfluss des Klimawandels und Anpassungsmaßnahmen in Form von Vorträgen mit Powerpoint vorgestellt.

Im Seminar werden mit den Studierenden aktuelle Themen zu Klimaschutz, Ingenieurökologie und Abwasserbiologie besprochen und diskutiert. In den Exkursionen bekommen die Studierenden vor Ort einen Einblick in technisch-biologische Großkläranlagen mit Labor (Mikroskopisches Bild), in naturnahe Abwasserreinigungsanlagen sowie in die Kanalisation München.

### **Media:**

Power-Point Präsentation, Tafel, Fallbeispiele, Exkursion / Demonstrationen

### **Reading List:**

Mudrack & Kunst: Biologie der Abwasserreinigung; Hacker & Johannsen: Ingenieurbiologie; Schönborn: Fließgewässerbiologie; Shilton eds.: Pond Treatment Technology; Janke: Umweltbiotechnik; Wissing: Abwasserreinigung in Pflanzenbeeten; BayLfU eds., Informationsbericht 1/99: Das Mikroskopische Bild bei der aeroben Abwasserreinigung, Schönwiese: Klimatologie; Handouts

### **Responsible for Module:**

Geist, Jürgen; Prof. Dr. rer. nat.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Aktuelle Themen zu Klimaschutz, Ingenieurökologie und Abwasserbiologie (Seminar, 1 SWS)  
Gschlößl T

Ingenieurökologie und Klimawandel in aquatischen Systemen (Vorlesung, 2 SWS)

Gschlößl T

Methoden der technischen und naturnahen Abwasserreinigung (Exkursion, 1 SWS)

Gschlößl T

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### WZ1171: Climate change related challenges in sewage treatment biology and engineering ecology | Klimabedingte Herausforderungen für Abwasserbiologie und Ingenieurökologie

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung erfolgt in Form einer 60-minütigen schriftlichen Prüfung. Anhand der Prüfung zeigen die Studierenden, dass sie zentrale Faktoren und Prozesse des Gewässerschutzes verstehen, die Ingenieurökologie im Hinblick auf biologische Abwasserreinigung und deren Zusammenhänge mit der Gefährdung aquatischer Biodiversität verstehen, biologische und naturnahe Abwasserreinigungssystemen bewerten können, wichtige Analysemethoden in der Abwasserreinigung verstehen sowie den Einfluss des Klimawandels und Anpassungsmaßnahmen verstehen.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Thematisches Interesse; Grundkenntnisse der biologischen Abwasserreinigung wären hilfreich, das Belegen anderer Lehrveranstaltungen aus dem Bereich der Aquatischen Ökologie wird empfohlen

#### Content:

Das Modul umfasst folgende Inhalte:

- Grundlagen des Gewässerschutzes (Gesetzgebung, Wasserrahmenrichtlinie, Geschichte und Entwicklung der biologischen Abwasserreinigung, Hygiene),
- Grundlagen Klimawandel (Klimapolitik in Bayern, EU, global, Klimaanpassungsforschung, Mitigation und Adaptation),
- Biologie der Abwasserreinigung (Mikroskopisches Bild, Nährstoffkreisläufe),

- Ingenieurökologie (Verfahren der technischen Abwasserreinigung, Abhilfemaßnahmen bei Betriebsstörungen anhand biologischer Indikatoren, Verfahren der naturnahen Abwasserreinigung, innovative Verfahren, wie Hygienisierung, Bioakkumulation, Biofiltration, Membranbelebung),
- Strategien und Methoden zum Schutz aquatischer Ökosysteme in Kläranlagen (Nährstoffe, Arzneimittelreste);
- Analytik und Untersuchungsmethoden bei der biologischen Abwasserreinigung

### **Intended Learning Outcomes:**

Nach erfolgreichem Abschluss dieses Moduls sind die Studierenden in der Lage,

- zentrale Faktoren und Prozesse des Gewässerschutzes zu verstehen;
- Ingenieurökologie im Hinblick auf biologische Abwasserreinigung und deren Zusammenhänge mit der Gefährdung aquatischer Biodiversität zu verstehen;
- biologische und naturnahe Abwasserreinigungssystemen zu bewerten;
- nachhaltige Schutzkonzepte für Gewässer zu entwickeln und zu bewerten;
- wichtige Analysemethoden in der Abwasserreinigung zu verstehen;
- den Einfluss des Klimawandels und Anpassungsmaßnahmen zu verstehen.

### **Teaching and Learning Methods:**

Das Modul besteht aus einer Vorlesung, einem Seminar und zwei Tagesexkursionen.

In der Vorlesung werden die zentralen Faktoren und Prozesse des Gewässerschutzes, die Ingenieurökologie im Hinblick auf biologische Abwasserreinigung und deren Zusammenhänge mit der Gefährdung aquatischer Biodiversität sowie der Einfluss des Klimawandels und Anpassungsmaßnahmen in Form von Vorträgen mit Powerpoint vorgestellt.

Im Seminar werden mit den Studierenden aktuelle Themen zu Klimaschutz, Ingenieurökologie und Abwasserbiologie besprochen und diskutiert. In den Exkursionen bekommen die Studierenden vor Ort einen Einblick in technisch-biologische Großkläranlagen mit Labor (Mikroskopisches Bild), in naturnahe Abwasserreinigungsanlagen sowie in die Kanalisation München.

### **Media:**

Power-Point Präsentation, Tafel, Fallbeispiele, Exkursion / Demonstrationen

### **Reading List:**

Mudrack & Kunst: Biologie der Abwasserreinigung; Hacker & Johannsen: Ingenieurbiologie; Schönborn: Fließgewässerbiologie; Shilton eds.: Pond Treatment Technology; Janke: Umweltbiotechnik; Wissing: Abwasserreinigung in Pflanzenbeeten; BayLfU eds., Informationsbericht 1/99: Das Mikroskopische Bild bei der aeroben Abwasserreinigung, Schönwiese: Klimatologie; Handouts

### **Responsible for Module:**

Geist, Jürgen; Prof. Dr. rer. nat.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Methoden der technischen und naturnahen Abwasserreinigung (Exkursion, 1 SWS)

Gschlößl T

Ingenieurökologie und Klimawandel in aquatischen Systemen (Vorlesung, 2 SWS)

Gschlößl T

Aktuelle Themen zu Klimaschutz, Ingenieurökologie und Abwasserbiologie (Seminar, 1 SWS)

Gschlößl T

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ1223: Climate, Climate Change and Land Use | Klima, Klimawandel und Landnutzung

Version of module description: Gültig ab winterterm 2018/19

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b>           | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung besteht aus einer Klausur (90 min). In der neunzigminütigen schriftlichen Klausur weisen die Studierenden nach, dass sie in der Lage sind, die vermittelten Methoden und erworbenen Kenntnisse für die Analyse interdisziplinärer Problemstellungen zu nutzen, die Zusammenhänge klar darzustellen und Konzepte zur Problemlösung zu entwickeln.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

keine

#### Content:

Das Modul umfasst folgende Inhalte:

- das Klimasystem mit seinen meteorologische Grundgrößen,
- Paläoklimatologie, natürliche Klimavariabilität, natürliche Antriebsfaktoren,
- Energie- und Stoffaustausch zwischen Ökosystemen und der Atmosphäre in verschiedenen Skalen,
- Rückkoppelungsprozesse zwischen Landoberfläche und Atmosphäre,
- Stadt- und Bioklimatologie
- anthropogene Einwirkungen auf das Klimasystem
- Klimawandel
- Lokale und regionale Veränderungen der Landnutzung und ihre skalenübergreifenden Auswirkungen auf das Klimasystem,
- Messungen
- Diskussion von aktuelle Forschungsentwicklung zu den Themen globaler Wandel anhand internationaler Veröffentlichungen

### **Intended Learning Outcomes:**

Nach erfolgreicher Teilnahme an diesem Modul sind die Studierenden in der Lage:

- das Klimasystem, seine Antriebsfaktoren, den anthropogenen Klimawandel sowie Treibhausgase und deren Wirkungsweise zu verstehen
- Sie können Auswirkungen des Klimawandels in natürlichen Systemen erkennen und klimatische Bedingungen und zukünftige Änderungen auf unterschiedlichen räumlichen Skalen abschätzen.
- Sie entwickeln ein problemorientiertes Verständnis des Wandels der Landbedeckung / -nutzung und den damit verbundenen Veränderungen im Klimasystem.
- Sie können die Wechselwirkungen zwischen spezifischen Klimaveränderungen, Mesoklimaten und unterschiedlichen Landnutzungssysteme und Städte analysieren.
- Sie können verschiedene Vermeidungs- und Anpassungsstrategien in der Landnutzung bewerten.

### **Teaching and Learning Methods:**

Das Modul besteht aus zwei Vorlesungen. In den Vorlesungen werden den Studierenden die Inhalte in Form von Powerpoint-Präsentationen vorgestellt und anhand konkreter Beispiele erklärt. Studierende sollen zum Studium der Literatur und der inhaltlichen Auseinandersetzung mit den Themen angeregt werden. Es werden zur Vertiefung des Inhalts aktuelle Publikationen zur Verfügung gestellt, die von den Studierenden im vorbereitenden Eigenstudium gelesen werden sollen und in der folgenden Vorlesung zusammengefasst und diskutiert werden. Beispielaufgaben werden zur Verfügung gestellt und teilweise besprochen.

### **Media:**

Präsentationen, digitaler Semesterapparat, Übungsaufgabensammlung

### **Reading List:**

IPCC (2013) Fifth Assessment Report Climate Change (AR5); Farmer GT & Cook J (2013): Climate Change Science: A Modern Synthesis, Volume 1 - The Physical Climate, Springer. Brasseur, Jacob & Schuck-Zöller (2017): Klimawandel in Deutschland, Springer. Zusätzliche Literatur wird in der Vorlesung vorgestellt und über Moodle zur Verfügung gestellt.

### **Responsible for Module:**

Annette Menzel amenzel@wzw.tum.de

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Klima, Klimawandel und Landnutzung (Vorlesung, 4 SWS)

Menzel A [L], Estrella N, Kloos S, Menzel A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ1590: Climate Change Economics | Climate Change Economics

Version of module description: Gültig ab winterterm 2014/15

|                                |                             |                                  |                                             |
|--------------------------------|-----------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>90                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

There will be a written exam (Klausur) of 90 minutes at the end of the semester. The students will be asked to demonstrate, within the stipulated amount of time using predefined methods and resources, their ability to outline the challenges climate change poses to regulators, propose pragmatic solutions and strategies as well as ways of implementing them. This would be based on the competences acquired from the relevant literature of economic modeling, theories of climate change and their understanding from the course content. The written exam is an appropriate assessment method to evaluate the degree to which the students understand the theoretical framework of climate change implications as well as provides an opportunity for them to put forward arguments based on existing theory.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge:

- Micro Economics (Welfare Economics)
- Environmental Economics
- Resource Economics

#### Content:

This course covers the trends in current and future climate change and their effects on economic and social outcomes.

The lectures are divided into ten sessions:

##### 1. Introduction to the Basic Science of Climate Change

- The students will learn about the scientific themes of global climate change and the economic dimension of the phenomenon.

## 2. Basic Economics

- The students will learn how a market economy can be efficient and socially optimal as well as about the prospects of externality.

## 3. Optimal Emission Levels

- The students will learn of the optimal abatement path and its uncertainty with respect to damages as well as Integrated Assessment Models (IAMs).

## 4. Intra-generational equity in climate policy

- The students will learn about how to account for equity across space (intergenerational equity) when deriving optimal emission levels.

## 5. International Environmental Agreements

- The students will learn about the dynamics behind common strategies towards achieving some form of optimal emission level.

## 6. Policy Instruments

- The students will learn about diverse instruments such as quality-based approach and Pigouvian Tax.

## 7. Regulation via Prices vs. Quantities

- The students will learn what circumstances will a regulator prefer prices over quantities and vice versa.

## 8. Credit-based Mechanisms

- The students will learn about how to deal with countries that do not want to commit, but have a high potential for low-cost reductions.

## 9. German Climate Policy

- The students will learn about German Climate Action - strategies and policies

## 10. European Union Emission Trading Scheme - EU ETS

### **Intended Learning Outcomes:**

After successfully completing the module, students are able to:

- Evaluate and formulate economic models related to climate change.
- Apply theoretical model to climate change regulations as well as policies that affect emission levels.
- Analyze the complexity, uncertainty and possibilities associated with optimal emission level.
- Apply appropriate instruments for optimal emission level that are efficient and cost-effective.
- Understand climate negotiations (club) and climate action strategies are currently being implemented.

### **Teaching and Learning Methods:**

The course mainly consists of lectures (4 SWS). The lecture will provide a foundation upon which to build the ensuing discussions on climate change issues from an economic perspective. The content of the module is expected to be transferred to the students in an interactive learning manner were, among others, emission reduction instruments are scrutinized. This encourages the students to independently and self-reliantly study the literature guided by a structured framework.

### **Media:**

PowerPoint, flipchart, internet portals, online reports etc.

**Reading List:**

Bréchet, T., & Eyckmans, J. (2009). Coalition theory and integrated assessment Modelling: Lessons for climate governance. *Global Environmental Commons: Analytical and Political Challenges in Building Governance Mechanisms*.

Rohling, M., & Ohndorf, M. (2012). Prices vs. quantities with fiscal cushioning. *Resource and Energy Economics*, 34(2), 169-187.

MacKenzie, I. A., & Ohndorf, M. (2012). Optimal monitoring of credit-based emissions trading under asymmetric information. *Journal of regulatory economics*, 42(2), 180-203.

Hake, J. F., Fischer, W., Venghaus, S., & Weckenbrock, C. (2015). The German Energiewende—history and status quo. *Energy*, 92, 532-546.

Climate Action Plan 2050 Principles and goals of the German government's climate policy. [https://www.bmu.de/fileadmin/Daten\\_BMU/Pool/Broschueren/klimaschutzplan\\_2050\\_en\\_bf.pdf](https://www.bmu.de/fileadmin/Daten_BMU/Pool/Broschueren/klimaschutzplan_2050_en_bf.pdf)

EU ETS Handbook. [https://ec.europa.eu/clima/sites/clima/files/docs/ets\\_handbook\\_en.pdf](https://ec.europa.eu/clima/sites/clima/files/docs/ets_handbook_en.pdf)

**Responsible for Module:**

Sauer, Johannes; Prof. Dr. agr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Climate Change Economics (WZ1590) (Vorlesung, 4 SWS)

Sauer J [L], Canessa C, Frick F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### WZ1821: Natural Resources - Traits, Management and Theory of Sustainability | Natural Resources - Traits, Management and Theory of Sustainability

*Natural Resources - Traits, Management, Theory of Sustainability*

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>80   | <b>Contact Hours:</b><br>70          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The intended learning outcomes as defined below require a differentiated way of examination. A written exam at the end of the semester will test whether the students sufficiently understand sustainability concepts and their connection to specific resources. As a midterm course achievement, external lecturer Dr. Savage offers the students topics for writing short reports about current global resource management problems as a homework, where they should show their ability to research and structure information and to identify crucial information gaps. Successful performance will improve the exam grade by 0.3.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

None

#### Content:

The module is intended to be a leitmotif during the first semester.

It consists of three basic units:

Unit 1 introduces the theory and the history of sustainability, supplemented by introducing interdisciplinary method knowledge.

Unit 2 introduces important natural resources, their specific traits in combination with sustainability challenges.

Unit 3 discusses case studies from interdisciplinary real-world-implementations.

Lecturers change during the semester. Each lecture is given by an expert in the specific field.

**Intended Learning Outcomes:**

At the end of the module the students understand the most important theories and perceptions of sustainable resource management as well as traits and challenges connected with essential natural resources. Moreover, they are able to apply this knowledge for critically questioning given real-world situations. This comprises the ability to assess strengths and weaknesses of given problem solution approaches (as presented in the media or specialist literature), and to outline possible approaches if confronted with a resource management problem.

**Teaching and Learning Methods:**

Depending on each lecture's specific contents and due to the modules' interdisciplinary character, teaching methods combine classic presentations, blended learning and group work.

**Media:**

presentations, worksheets, simulation models

**Reading List:**

Recommended up-to-date readings are supplied by the specific lecturers

**Responsible for Module:**

Biber, Peter; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Natural Resources - Traits, Management, Theory of Sustainability (Vorlesung, 5 SWS)

Biber P [L], Biber P, Grambow M, Häberle K, Kasperidus H, Knoke T, Kohlpaintner M, Kunkowski T, Menzel A, Pretzsch H, Savage C, Schad P, Teixeira Pinto L

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ1825: Soil Science | Bodenkunde

Version of module description: Gültig ab winterterm 2019/20

|                                  |                            |                                   |                                             |
|----------------------------------|----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Bachelor | <b>Language:</b><br>German | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>5            | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>75    | <b>Contact Hours:</b><br>75                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Prüfungsleistung wird in Form einer benoteten Klausur (120 min) erbracht, zu der keine Hilfsmittel zugelassen sind. Die Studierenden zeigen, dass sie die grundlegenden Eigenschaften der Böden kennen und die Kausalbeziehungen zwischen diesen verstanden haben. Sie kennen die wichtigsten menschlichen Eingriffe in den Boden und können die Folgen dieser Eingriffe für die Funktionalität der Böden bewerten. Sie zeigen, wie man anhand von Bodenprofilen unter Anwendung der Grundlagenkenntnisse Böden beschreiben, ihre Entstehung ableiten und ihre ökologischen Eigenschaften bewerten kann.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Grundlegende Kenntnisse in Naturwissenschaften, insbesondere Chemie.

#### Content:

- Bodenkundliche Grundbegriffe,
- anorganisches und organisches Ausgangsmaterial,
- Prozesse der Umwandlung,
- chemische, physikalische und biologische Eigenschaften der Böden,
- Bodengenese,
- Bodentypenlehre,
- anthropogene Böden,
- Bodendegradation (Verdichtung, Erosion),
- Stoffkreisläufe,
- Bodenschutz,
- Bodenbeschreibung,
- Bodenklassifikation,

- Bodenbewertung.

### **Intended Learning Outcomes:**

Nach dem erfolgreichen Besuch des Moduls sind die Studierenden in der Lage, die Entstehung von Böden und die kausalen Zusammenhänge zwischen ihren verschiedenen Eigenschaften zu verstehen. Sie können die Eingriffe des Menschen in die Funktionalität der Böden bewerten. Darüber hinaus sind sie in der Lage, Böden anhand von Bodenprofilen im Gelände zu beschreiben und ökologisch zu bewerten.

### **Teaching and Learning Methods:**

Die Vorlesung „Einführung in die Bodenkunde“ vermittelt die Grundlagen über den Boden als Naturkörper. Die Vorlesung „Angewandte Bodenkunde“ baut darauf auf und erläutert die Auswirkungen des menschlichen Eingreifens in den Boden (zielgerichtet zu dessen Nutzung oder als Auswirkungen anderer Eingriffe). In den Vorlesungen wird der Stoff den Studierenden von der Dozentin präsentiert, wobei Powerpoint-Dateien zu Hilfe genommen werden. Fragen und Diskussionsbeiträge der Studierenden sind erwünscht. Bei den Geländeübungen lernen die Studierenden in kleinen Gruppen die Beschreibung und Bewertung von Böden anhand von Bodenprofilen an verschiedenen Standorten und wenden dabei das in den Vorlesungen vermittelte Wissen an. Diese Fähigkeiten können nur im Gelände im direkten Kontakt zwischen Lehrenden und Studierenden erworben werden.

### **Media:**

Vorlesungen: PowerPoint-Präsentationen mit Downloadmöglichkeit. Übungen: Spaten, Spachtel, Wasser, pH-Stäbchen, Bohrstock, Kartieranleitung, Skript.

### **Reading List:**

1. Scheffer-Schachtschabel, Lehrbuch der Bodenkunde, Springer-Spektrum, 17. Auflage, Heidelberg, 2018.
2. Gisi U., Bodenökologie, Thieme-Verlag, 2. Auflage, Stuttgart, 1997.
3. Hintermaier-Erhard G. und Zech W., Wörterbuch der Bodenkunde, Enke-Verlag, Stuttgart, 1997.
4. Blum W., Bodenkunde in Stichworten, Gebr. Borntraeger, Stuttgart, 7. Auflage, 2012.
5. Ad-hoc-AG Boden, Bodenkundliche Kartieranleitung, 5. Auflage, Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 2005

### **Responsible for Module:**

Kögel-Knabner, Ingrid; Prof. Dr. rer. nat. Dr. rer. nat. habil.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Angewandte Bodenkunde (Vorlesung, 1 SWS)  
Kögel-Knabner I, Schad P

Einführung in die Bodenkunde (Vorlesung, 2 SWS)  
Kögel-Knabner I, Schad P

Grundlagen der Feldbodenkunde, prüfungsrelevante Übungstage (Übung, 2,1 SWS)  
Schad P [L], Schad P, Schweizer S, Bucka F, Just C, Reifschneider L, Völkel J, Putzhammer S  
For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ2673: Basics Aquatic Ecology and Conservation | Grundlagen Ökologie und Schutz von Gewässersystemen

Version of module description: Gültig ab summerterm 2018

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150         | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Current information regarding the limited activities with physical presence due to the CoViD19-pandemic:

In case the framework requirements (hygienie, distance rules etc.) for examinations with physical presence are not met, the planned examination format can be changed to a digital (remote) examination according to §13a APSO. The decision on this change will be communicated as soon as possible, however latest 14 days before the actual examination date, by the responsible examiner in coordination with the examinations board.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Thematisches Interesse; das Belegen anderer Lehrveranstaltungen aus dem Bereich der Aquatischen Ökologie ist keine Voraussetzung

#### Content:

Das Modul umfasst folgende Inhalte:

- Bedeutung aquatischer Ökosysteme für den Menschen,
- Ökosystemfunktionen,
- Eigenschaften des Lebensraums Wasser,
- Gashaushalt,
- Nährstoffe und deren Dynamik,
- Bioindikationsmethoden,
- Gefährdungsfaktoren aquatischer Biodiversität,
- Ökologie und Gefährdung von Fließgewässern,

- Ökologie und Gefährdung von stehenden Gewässern,
- Aquatische Ökotoxikologie,
- Strategien zum Schutz aquatischer Biodiversität;
- Untersuchungsmethoden und Arbeitsweisen in der Aquatischen Systembiologie.

**Intended Learning Outcomes:**

Nach erfolgreichem Abschluss dieses Moduls sind die Studierenden in der Lage,

- zentrale Faktoren und Prozesse in Gewässerökosystemen und deren Zusammenhänge mit der Gefährdung aquatischer Biodiversität zu verstehen;
- anthropogenen und natürlichen Störungen aquatischer Ökosysteme zu bewerten;
- ganzheitliche Schutzkonzepte für Gewässer zu entwickeln und zu bewerten;
- wichtige Mess- und Untersuchungsmethoden in der Aquatischen Systembiologie zu kennen.

**Teaching and Learning Methods:**

Das Modul besteht aus einer Vorlesung und einem Seminar. In der Vorlesung werden wichtige Mess- und Untersuchungsmethoden in der Aquatischen Systembiologie sowie zentrale Faktoren und Prozesse in Gewässerökosystemen und deren Zusammenhänge mit der Gefährdung aquatischer Biodiversität erläutert. Es werden anthropogene und natürliche Störungen aquatischer Ökosysteme erklärt und ganzheitliche Schutzkonzepte für Gewässer vorgestellt.

Im Seminar werden anthropogene und natürliche Störungen aquatischer Ökosysteme und Schutzkonzepte für Gewässer anhand konkreter Fallbeispiele bewerten. Das Seminar kann sowohl im Sommersemester als auch im Wintersemester belegt werden.

**Media:**

Power-Point Präsentation, Tafel, Flip-chart, Handzettel, Fallbeispiele, praktische Übungen / Demonstrationen

**Reading List:**

Pullin AS Conservation Biology; Cambridge University Press; Primack R.B. A primer of conservation biology; Sinauer Ass.; Gleick PH The world's water Report on Freshwater Resources; further reading material will be announced

**Responsible for Module:**

Geist, Jürgen; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Aquatic Ecology and Conservation V (Vorlesung, 2 SWS)

Geist J

Lösung wissenschaftlicher Probleme in Gewässerökologie und Aquakultur (Seminar, 2 SWS)

Geist J, Beggel S, Kühn R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ2733: Introduction to Soil Science | Introduction to Soil Science

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>80   | <b>Contact Hours:</b><br>70          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In a written exam of 60 minutes duration, the students demonstrate by answering questions without helping material their understanding of the nature and properties of soils, and they remember the characteristics of the soils of the field course as well the field assessment methods. In a pass/fail exam (laboratory assignment) in the field of 10 minutes duration, they prove their ability to survey and interpret a soil profile.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in chemistry, physics, and biology.

#### Content:

- What is a soil?
- Mineral (inorganic) soil components
- Soil biology and soil organic matter
- Soil chemistry
- Soil physics
- Soil-forming processes
- Soil survey
- Soil interpretation
- Soil erosion assessment

#### Intended Learning Outcomes:

The students understand the basics of soil science. They can use their knowledge from soil mineralogy, soil organic matter, soil chemistry, and soil physics to understand soil formation



processes and important biochemical and physical properties. The students are able to survey a soil profile and to detect the genesis of the surveyed soil. They can evaluate the possibilities of soil use, the risks to the soil itself and the risks to its environment. They are able to evaluate the hydrology of the soil and to judge the erosion risk.

**Teaching and Learning Methods:**

The lecture discusses the essentials of soil science. The field assessment starts with peer instructions to analyse a soil profile. During the course, the students will do more and more group work to train the evaluation of a soil profile, its hydrology and its erosion risks.

**Media:**

Lecture: presentation notes. Field Assessment: spade, auger, knife, colour charts, TDR probes, suction cups, erosion assessment kits.

**Reading List:**

Brady, Weil: The nature and properties of soils, 14th edition, 2007.

Blume et al.: Scheffer/Schachtschabel Soils science, 2016.

Eash, Sauer, O'Dell, Odoi, Bratz: Soil science simplified, 6th edition, 2016.

Blum, Schad, Nortcliff: Essentials of Soil Science, 2016.

FAO Guidelines for Soil Description. Prepared by Jahn, Blume, Asio, Spaargaren, Schad, 2006.

**Responsible for Module:**

Schad, Peter; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Introduction to Soil Science: Lecture (Vorlesung, 2 SWS)

Schweizer S

Introduction to soil science: Field course (Übung, 3,5 SWS)

Wiesmeier M [L], Wiesmeier M, Garcia Franco N, Völkel J, Putzhammer S, Schad P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ2734: Soil Protection | Soil Protection

Version of module description: Gültig ab winterterm 2015/16

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In an oral exam of 30 minutes duration, students demonstrate in a scientific discussion by answering questions without helping material their broad and deep understanding on how to protect soils. The understanding of soils, as achieved in the modules "Introduction to soil science" and "World soil resources", is implicitly part of the oral exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The successful completion of the module "Introduction to Soil Science" or equivalent skills are required. The successful completion of the module "World Soil Resources" is recommended.

#### Content:

Principles of soil degradation, the world food problem, highly erodible soils, semi-arid environments (including irrigation and salinization problems), kaolinitic soils, shifting cultivation, organic and mineral fertilization, agroforestry, land use and greenhouse gases, soil functions, organic pollutants, inorganic pollutants (heavy metals), radionuclides, pesticides, pathways of pollutants, sorption, precipitation, co-precipitation, acidification, ways to assess the mobility of pollutants, remediation of brownfields.

#### Intended Learning Outcomes:

The students are able to apply their knowledge of soils, as achieved in the modules "Introduction to Soil Science" and "World Soil Resources", to develop strategies of soil protection. They understand the major environmental factors that determine the food production in the world. They are able to address the specific problems of highly erodible soils, semi-arid land and kaolinitic soils and to design adequate land-use methods. The students understand the major factors that determine the fate of substances in soil. They are able to analyze and forecast the fate of heavy metals, organic

pollutants and radionuclides in soil and are familiar with important techniques for managing and remediating brownfields.

**Teaching and Learning Methods:**

Lecture, discussions

**Media:**

Presentation notes.

**Reading List:**

Blanco, H., Lal, R. (2008): Principles of soil conservation and management. Diamond, J. (1998): Guns, germs and steel. A short history of everybody for the last 13,000 years. Mirsal, I. (2008): Soil Pollution.

**Responsible for Module:**

Schad, Peter; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Bodenschutz - Organische und anorganische Schadstoffe in Böden (Vorlesung, 2 SWS)  
Bucka F

Soil Protection and World Food Production (Vorlesung, 2 SWS)

Schad P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ2735: World Soil Resources | World Soil Resources

Version of module description: Gültig ab winterterm 2015/16

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>80   | <b>Contact Hours:</b><br>70          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In an oral exam of 30 minutes duration, students demonstrate in a scientific discussion by answering questions without helping material their fundamental understanding of the soils of the world in relation to other ecological factors, and they remember the soils of the field course as well as the methods of surveying and classifying soils in the field. In a pass/fail exam (laboratory assignment) in the field of 10 minutes duration, they prove their ability to survey and classify soils of various landscapes and environmental settings. The understanding of soils, as achieved in the module "Introduction to soil science" is implicitly part of the oral exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The successful participation at the module "Introduction to Soil Science" (which is given in the first half of the summer semester) is required.

#### Content:

- Soils of the world
- Chemical, biological and physical properties of soils
- Genesis of soils as the result of -soil-forming processes
- Soil survey
- Soil classification according to the international system
- Soil interpretation.

#### Intended Learning Outcomes:

The students are able to apply their knowledge of soils, as achieved in the module "Introduction to Soil Science", to all soils of the world. The students understand the characteristics of the soils of the world, the pattern of their geographical distribution, their genesis, their ecological potential and

the threats to their functions. The students are able to survey a soil profile, to detect the genesis of the surveyed soil and to classify it according to the international soil classification system. They are able to evaluate the possibilities and risks of soil management. They can assess the relationship between the soil and its environmental setting.

**Teaching and Learning Methods:**

The lecture gives an overview of all soils of the world. The field course (several days) presents soils in a landscape outside southern Bavaria. The students are trained in the methodological skills of soil survey, soil classification and soil interpretation.

**Media:**

Lecture: presentation notes. Field Assessment: spade, auger, knife, colour charts.

**Reading List:**

FAO Guidelines for Soil Description. Prepared by Jahn, Blume, Asio, Spaargaren, Schad, 2006.  
IUSS Working Group WRB: World Reference Base for Soil Resources 2014. Update 2015.  
Prepared by Schad, van Huyssteen, Micheli. FAO World Soil Resources Reports 106.

**Responsible for Module:**

Schad, Peter; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Bodenansprache und Bodenklassifikation nach internationalen Standards (Übung, 2,8 SWS)  
Schad P

World Soil Resources: Lecture (Vorlesung, 2 SWS)

Schad P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ4229: Development and Application of Ecological Simulation Models | Entwicklung und Anwendung ökologischer Simulationsmodelle

Version of module description: Gültig ab winterterm 2016/17

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>105  | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Studierenden präsentieren die Ergebnisse des Projekts in einer Kurzpräsentation und verfassen einen Bericht, in dem die Modellentwicklung und Modellauswertung dokumentiert wird. Durch die Projektarbeit weisen die Studierenden nach, dass sie komplexe ökologische Sachverhalte in Modellen darstellen können und Modelle in graphischen Simulationsumgebungen oder dynamischen Programmiersprachen implementieren können. Mit dem Bericht und der Präsentation zeigen die Studierenden, dass sie komplexe ökologische Sachverhalte analysieren und die Ergebnisse ihres Projekts in geeigneter Weise aufbereiten und einer Zuhörerschaft präsentieren können.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Teilnahme an „Analyse und Modellierung Dynamischer Systeme“ (Biber) und/oder „Bachelorprojekt Auswirkungen von Waldbrand und Borkenkäferkalamitäten auf die Walddynamik: Entwicklung und Anwendung von einfachen Simulationsmodellen“ (Rammig/Zang).

#### Content:

Ökologische Simulationsmodelle helfen uns, ökologische Zusammenhänge und die Funktionsweise von Ökosystemen (oder Teilen davon) besser zu verstehen. Das erklärt ihr breites Anwendungsfeld, z.B. für Ressourcenmanagement, Forstwirtschaft und Artenschutz. In diesem Modul werden tiefergehende Kenntnisse zur ökologischen Modellierung erarbeitet. Dabei wird mit der Implementation von einfachen dynamischen Modellen in einer graphischen Simulationsumgebung (z.B. Vensim) begonnen und idealerweise der Schritt hin zu einer allgemeinen dynamischen Programmiersprache (z.B. R) vollzogen. Das Modul beinhaltet eine

Einführung in den Umgang mit einer graphischen Simulationsumgebung (z.B. Vensim) und dynamischer Programmierung (z.B. R). Behandelte Themen umfassen:

- Einfache Populations- und Wachstumsmodelle - Modellierung von Räuber-Beute-Beziehungen
- Simulation von Ressourcenübernutzung
- Modellierung von gekoppelten dynamischen Systemen (z.B. Klimawandel-Feuer-Feedbacks, Borkenkäferbefall)
- Ökosystemmodellierung

### **Intended Learning Outcomes:**

Nach Teilnahme an diesem Modul sind die Studierenden in der Lage, komplexere ökologische Sachverhalte in Modellen darzustellen. Sie sind somit in der Lage, sich durch Modellierung ein tiefergehendes Verständnis des betrachteten Systems zu erarbeiten. Die Studierenden sind in der Lage, Modelle in einer graphischen Simulationsumgebung oder mit einer dynamischen Programmiersprache (R) zu implementieren. Die Studierenden sind in der Lage, Fähigkeiten und Grenzen dynamischer Modellierungsansätze zu erkennen und diese passend aufzubereiten und zu präsentieren.

### **Teaching and Learning Methods:**

Das Modul setzt sich aus einer Vorlesung und einer Übung zusammen. In der Vorlesung werden die theoretischen Grundlagen von den Dozenten in Form von Vorträgen und Präsentationen vermittelt. In der Übung werden von den Studierenden folgende Aufgaben als Einzelarbeit durchgeführt:

- Formulierung der wissenschaftlichen oder management-relevanten Fragestellungen und Literaturrecherche
- Recherche der nötigen Hintergrundinformationen
- Entwicklung eines konzeptionellen Modells - Implementierung des Modells in einer Simulationsumgebung (z.B. „Vensim“) und idealerweise in einer dynamischen Programmiersprache
- Durchführung von Modellsimulationen
- Szenarienanalyse
- Auswertung der Ergebnisse und graphische Darstellung
- Ergebnisse in einem Kurzvortrag präsentieren und diskutieren

Dokumentation des Modells und der Modellergebnisse in einem Bericht, Maximale Teilnehmerzahl: 8

### **Media:**

Vorlesung mit Powerpoint und Übung am Computer. Modellentwicklung in Gruppenarbeit. Literaturrecherche.

### **Reading List:**

Smith & Smith (2007) Introduction to Environmental Modeling, Oxford University Press.  
Soetaert & Herman (2009) A Practical Guide to Ecological Modelling, Springer.  
Weitere Fachliteratur für Fallbeispiele.

**Responsible for Module:**

Rammig, Anja; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Lehrveranstaltung 1: Entwicklung und Anwendung ökologischer Simulationsmodelle

Vorlesung (1 SWS)

Lehrveranstaltung 2:

Entwicklung und Anwendung ökologischer Simulationsmodelle

Übung (2 SWS)

Anja Rammig, Christian Zang

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### WZ6108: Instruments of Spatial Planning | Planungsinstrumente der Landschaftsplanung

Version of module description: Gültig ab summerterm 2018

|                                |                            |                                   |                                             |
|--------------------------------|----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150 | <b>Self-study Hours:</b><br>90    | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Die Modulprüfung besteht aus einer Klausur, in der die Studierenden planungswissenschaftlich und/oder für die Praxis wichtige Merkmale der verschiedenen Planungsinstrumente der ökologisch-ästhetisch orientierten Raumplanung (Landschaftsplanung i.w.S.) ohne Hilfsmittel abrufen und erinnern sollen. Bei den Merkmalen handelt es sich um die Ziele und die inhaltlichen Gegenstände der Planungsinstrumente, um Vorgehensweisen und Methoden des Planers sowie um die Abläufe der Planungs- und Verwaltungsverfahren, in die die Instrumente eingebettet sind. Die Beantwortung der Fragen erfordert eigene Formulierungen. Durch die eigenen Formulierungen sollen die Studierenden zeigen, dass sie die Charakteristika der Planungsinstrumente richtig verstanden haben. Für die Beantwortung der Fragen stehen 90 Minuten zur Verfügung.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

#### Content:

Das Modul gibt einen Überblick über das System ökologisch-ästhetisch orientierter Planungen. Zugrunde gelegt ist ein sehr weites Verständnis von Landschaftsplanung. Die Lehrveranstaltungen lassen sich inhaltlich grob in drei Blöcke unterteilen: 1. Instrumente der Umweltfolgenprüfung und -bewältigung (Strategische Umweltprüfung und Umweltverträglichkeitsprüfung, Eingriffsregelung, Verträglichkeitsprüfung nach der FFH-Richtlinie, artenschutzrechtliche Prüfung, ). 2. Die Instrumente der gesetzlichen Landschaftsplanung (Landschaftsprogramm, Landschaftsrahmenplan, Landschaftsplan, Grünordnungsplan). 3. Informelle Instrumente proaktiver, entwickelnder Raumplanung (z. B. Regionale Entwicklungskonzepte, Konzepte der Integrierten ländlichen Entwicklung, Landschaftsentwicklungskonzepte, Freizeit-

und Erholungsplanung). Die genannten Planungsinstrumente werden hinsichtlich ihrer Verfahrensabläufe (Übersicht) sowie der bei der Bearbeitung eingesetzten Vorgehensweisen und Methoden (Schwerpunkt der Lehrveranstaltung) vorgestellt, an Beispielen veranschaulicht sowie in ihrer Leistungsfähigkeit kritisch reflektiert. Besonderer Wert wird darauf gelegt, die Verbindungen und Unterschiede zwischen einzelnen Instrumenten darzustellen sowie jüngere Entwicklungen einzubeziehen, z. B. die sog. produktionsintegrierte Kompensation, bei der Nutzungsintensivierung bzw. -umstellung als Kompensationsmaßnahme eingesetzt wird.

### **Intended Learning Outcomes:**

Nach der Teilnahme an den Modulveranstaltungen kennen und verstehen die Studierenden die verschiedenen Planungsinstrumente (Ziele, Schutzgüter, rechtliche Regelungssystematik), wichtige Vorgehensweisen der Landschaftsplanung sowie ausgewählte Verfahren, in die die Planungsinstrumente eingebettet sind.

### **Teaching and Learning Methods:**

Die Inhalte der Vorlesung werden über Vortrag und PowerPointpräsentation vermittelt. Andere Lehrmethoden sind aufgrund der großen Teilnehmerzahlen (40 bis 90) schwer zu integrieren. Die Inhalte werden durch Praxisbeispiele veranschaulicht. Durch Hinweise während der Vorlesung und noch einmal vor der Prüfung wird verdeutlicht, was obligatorisches Kernwissen ist und was Beispiele oder zusätzlich erläuternde Ausführungen sind. Durch gezielte Fragen, die zum Mitdenken anregen sollen, werden die Studierenden in der Vorlesung aktiviert.

Die Vorlesung hat die Aufgabe, den Studierenden, die die Planungsinstrumente der Landschaftsplanung aus dem Vorstudium noch nicht kennen, kompakt die Planungsinstrumente vorzustellen und die wesentlichen Eigenschaften zu vermitteln. Das geht am besten in einer Vorlesung. 4 SWS Vorlesung in einem Semester zu diesen Inhalten sind aber didaktisch aus Sicht des Modulverantwortlichen nicht sinnvoll. Aus diesem Grund wird der Stoff auf zwei Semester verteilt.

### **Media:**

PowerPointpräsentationen

### **Reading List:**

Haaren, C. von (2004): Landschaftsplanung. Stuttgart, Ulmer.

Jessel, B. & Tobias, K. (2002): Ökologisch orientierte Planung. Stuttgart, Ulmer;

Köppel, J., Peters, W. & Wende, W. (2004): Eingriffsregelung, Umweltverträglichkeitsprüfung, FFH-Verträglichkeitsprüfung. Stuttgart, Ulmer.

### **Responsible for Module:**

Wolfgang Zehlius-Eckert [zehlius@mytum.de](mailto:zehlius@mytum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Instrumente der Landschaftsplanung II/Planungsinstrumente der proaktiven

Landschaftsentwicklung (Vorlesung, 2 SWS)

Zehlius-Eckert W [L], Zehlius-Eckert W

Instrumente der Landschaftsplanung II/Planungsinstrumente der proaktiven  
Landschaftsentwicklung (Vorlesung, 2 SWS)  
Zehlius-Eckert W [L], Zehlius-Eckert W

Einführung in die Planungsinstrumente der Landschaftsplanung (Vorlesung, 2 SWS)  
Zehlius-Eckert W [L], Zehlius-Eckert W  
For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ8100: Fundamentals of Climate Change | Fundamentals of Climate Change

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The written exam at the end of the term lasts 60 minutes. Here the students show without any additional help that their ability to answer questions concerning natural and anthropogenic causes and impacts of climate change on physical and biological systems on the basis of the topics of the lecture. The students shall prove that they are able to understand basic connections between causes and impacts of climate change

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in meteorology, physics

#### Content:

This modul gives an overview on the theoretical background on the physical science basis of climate change, resulting observed changes in various physical biological and biogeochemical systems, and anthropogenic attribution, additionally actions for mitigation are introduced. This lecture is based on the newest IPCC report (AR 5).

#### Intended Learning Outcomes:

Students will become familiar with current knowledge concerning mechanism of climate change as well as climate change impacts on environment. They are able to analyse data and interpret the results. They have the knowledge to detect impacts of climate change in natural systems.

**Teaching and Learning Methods:**

Students will become familiar with current knowledge concerning mechanism of climate change as well as climate change impacts on environment. They are able to analyse data and interpret the results. They have the knowledge to detect impacts of climate change in natural systems.

**Media:**

IPCC (2013) Fifth Assessment Report of WGI, II, III. Houghton (2015) Global warming, the complete briefing. Most recent scientific literature

**Reading List:**

IPCC (2013) Fifth Assessment Report of WGI, II, III. Houghton (2015) Global warming, the complete briefing. Most recent scientific literature

**Responsible for Module:**

Estrella, Nicole; Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Fundamentals of Climate Change (Vorlesung, 2 SWS)

Estrella N

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Cross Cutting Methods | Fächerübergreifende Methoden

### Module Description

#### **BGU900013: Partner University - Elective Module | Partneruniversität - Wahlmodul**

Version of module description: Gültig ab winterterm 2013/14

|                      |                     |                          |                       |
|----------------------|---------------------|--------------------------|-----------------------|
| <b>Module Level:</b> | <b>Language:</b>    | <b>Duration:</b>         | <b>Frequency:</b>     |
| <b>Credits:*</b>     | <b>Total Hours:</b> | <b>Self-study Hours:</b> | <b>Contact Hours:</b> |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

#### **Content:**

#### **Intended Learning Outcomes:**

#### **Teaching and Learning Methods:**

#### **Media:**

#### **Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU38013: Technical Communication Skills in Water and Wastewater Treatment Engineering | Präsentationstechniken anhand ausgewählter Kapitel der Siedlungswasserwirtschaft**

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The exam consists of a presentation (30 minutes incl. Q&A). The understanding and application skills of scientific work and communication competence are evaluated. By the presentation the students shall prove that they are able to understand and evaluate a complex scientific topic and by the use literature research in the library and online-databases and that they are capable to create their findings in a sophisticated presentation. Next to the content presentation style as well as the layout are part of the evaluation.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basic Module Siedlungswasserwirtschaft (oder äquivalent)

#### **Content:**

1. Lectures Giving Talks, including Preparing for a Lecture, Communicational Aspects, Powerpoint Use and Literature Search Engines and Reference Management Software
2. Preparing a Report regarding a Topic from Water and Wastewater Treatment Engineering
3. Preparing an own Lecture with the same Topic from Water and Wastewater Treatment Engineering
4. Testing the own Lecture with the Topic from Water and Wastewater Treatment Engineering with Feedback meeting .
5. Final Lecture



**Intended Learning Outcomes:**

At the end of the module, students are able to understand and evaluate scientific publications in the field of urban water technology. Furthermore, they can evaluate the results of research projects and create a scientific presentation

**Teaching and Learning Methods:**

A series of lectures teaches methods in scientific paper writing and presentation skills. The work on the own seminar topic is carried out independently under the guidance of tutors. A mid-term evaluation and feedback is given during several intermediate sessions. (literature review, trial presentation, examination Lecture)

**Media:**

Präsentation, Internet, Handouts, Talks

**Reading List:**

List of references will be announced by the tutor after topic selection for the presentation in the first seminar.

**Responsible for Module:**

Prof. Dr.-Ing Jörg Drewes (jdrewes@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Technical Communication Skills in Water and Wastewater Treatment (Seminar, 2 SWS)

Drewes J, Koch K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU38018: Planning Processes and Clearance According to German and European Law | Planungs- und Genehmigungsverfahren nach deutschem und europäischem Wasserrecht**

Version of module description: Gültig ab winterterm 2015/16

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The assessment of learning outcomes will be carried out by evaluation of a study project worked on in a group of two or more and accompanied by a closing presentation.

Aim of the report is the assessment of the students' ability to analyze and evaluate a determined case example in the environmental field. The students shall prove the ability to identify and apply case related legal requirements and derive the corresponding consequences for planning and clearance.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Environmental law (bsc.-Level)

#### **Content:**

The lecture provides knowledge about regulations based on the German "Wasserhaushaltsgesetz". Legal requirements concerning water quality and discharge permissions respectively regarding water technologies and industry are being dealt with. Moreover flood and flood prevention measures as well as the clearance of hydraulic engineering of constructions measures in common water systems and water preserves are illustrated. Additionally regulation based consequences for engineering and design are being discussed among planning and approval procedures. Next to German regulations the European legislation is part of the lecture in terms of interdependency and administrative procedures on national and international level.

**Intended Learning Outcomes:**

After the module lecture series the students are able to understand and remember the concepts and processes of approval procedures especially in the water sector. They are able to understand clearance processes and legal measures as well as administrative procedures for construction measures in the water environment. Moreover they are able to predict and derive the administrative processes as well necessary engineering and design measures for specific cases.

**Teaching and Learning Methods:**

The theoretical Background and the current guidelines are presented in lectures. Case studies and exercises assist the work on problems discussed in the lecture as practical application and preparation for the future communication in/with the public sector.

**Media:**

Powerpoint presentations; Exercises in class

**Reading List:**

will be announced in class

**Responsible for Module:**

Prof.-Dr. Drewes: <a href="mailto:jdrewese@tum.de">jdrewese@tum.de</a>

**Courses (Type of course, Weekly hours per semester), Instructor:**

Planungs- und Genehmigungsverfahren nach deutschem und europäischem Wasserrecht  
(Seminar, 2 SWS)

Spieler M [L], Spieler M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU43012T2: Technical Acoustics | Technische Akustik

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120   | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcomes of module Technical Acoustics are assessed by two thematically separated exams at the end of the respective semester. The first exam is a written exam lasting 60 minutes and the second exam is an oral exam with 20 minutes duration. Both exams contribute equally to the module's grade. In the summer term, the first exam is held as a oral exam with 20 minutes duration due to the Covid-19 pandemic.

The aim of the first examination is the confirmation that the key acoustic concepts which relate to complex quantities and Fourier Transformations have been understood and can be concisely recalled and implemented. The student should, for example, be able to understand, repeat and apply the basics about the origins, perception and weighting of sound as well as the prediction of sound fields as a result of different sound sources. Furthermore, problems must be analyzed and solution approaches found within a limited time using the learning outcomes achieved during the module.

The aim of the second examination is the confirmation that the basics of Statistical Energy Analysis (SEA) have been understood and that the underlying content can be repeated. The principles of Room Acoustics such as sound propagation and modification in open space as well as the formation of flow induced noise should be understood and applied to small problem formulations. Furthermore, problems must be analyzed and solution approaches found and also implemented within a limited time using the learning outcomes achieved during the module.

The solutions sometimes require the students own interpretations.

A non-programmable calculator is the only auxillary means allowed in the exam.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basic knowledge in Structural Dynamics

Basic knowledge in Logarithm Calculus and calculating with Complex Numbers

**Content:**

In this module the key contents of Technical Acoustics are handled.

The thematic outline is as follows:

- Transformations Time-Frequency Domain
- Calculation with complex variables
- Perception of sound (Law of Weber Fechner, calculation with sound level and effective values, Frequency dependent perception and their standards, time dependent sound levels)
- Prediction of sound fields (Superposition of coherent/incoherent sound sources, wave propagation in two and three dimensions, sound velocity, intensity and power)
- Sound radiation (Sound source types, plate radiation, structure borne sound, coincidence cut off frequency)
- Absorption (Types of absorption, Impedance)
- Statistical Energy Analysis (Method, limitation of the method, evaluation)
- Sound propagation in open space (diffraction, noise protection barriers design)
- Flow induced noise (Lighthill analogy)
- Room Acoustic (Physical foundation, impulse response, room acoustic assessment criteria, music room design)

**Intended Learning Outcomes:**

After the successful participation in this module, students are able to understand the fundamental theoretical context of Technical Acoustics and implement them on tasks. The fundamental basics of Statistical Energy Analysis as well as the mechanisms of formation and characterization of flow induced noise will be understood after their participation. Based on their basic knowledge on complex numbers and calculation of logarithms, they are able to calculate sound pressure and predict sound fields in open spaces as well as within closed rooms. Furthermore, students can evaluate, using fundamental physical principles, the mechanisms of sound radiation and absorption, their characteristics, and the measures employed to influence them. The students know the most important acoustical parameters of rooms as well as the requirements, which are described with the help of these parameters for different rooms. Therefore, they can analyze the acoustical quality of a room. Based on their knowledge of physical fundamentals of different absorbers, the students can design measures in order to improve the acoustical quality.

**Teaching and Learning Methods:**

The module comprises of a lecture which is held with the help of a tablet PC as well as a digital projector. The lecturer is hereby able to clearly convey the fundamental aspects of Technical Acoustics, show the relevance through application of the current themes as well as present practical and research orientated examples from their field, motivating the student to involve themselves in the topic. The lecturers work with notes to which additions can be made with a tablet PC, allowing discussions during the lecture to be integrated into the course documentation. On top of lectures, integrated seminars should help the student to apply the basics and concepts to real problem cases. Students will be supplied with calculation exercise sheets to help deepen their understanding and practical application.

**Media:**

As well as the lecture notes on tablet PC and digital projector, slides or lecture hall blackboard may be used. Exercise sheets are published online. Audio samples will be used selectively to illustrate the contents. The measurement of important acoustical parameters of rooms is explained with practical orientation during a measuring exercise. A field trip will be, if possible, organized to a technical acoustic consultancy firm.

**Reading List:**

Müller, Gerhard ; Möser, Michael: Taschenbuch der Technischen Akustik, Springer, 2004  
Müller, Gerhard ; Möser, Michael: Handbook of Engineering Acoustics, Springer, 2013  
Möser, Michael: Technische Akustik, Springer, 2005

**Responsible for Module:**

Prof. Dr.-Ing. Gerhard Müller

**Courses (Type of course, Weekly hours per semester), Instructor:**

Technical Acoustics 1 (Vorlesung mit integrierten Übungen, 2 SWS)  
Müller G, Freisinger J

Technical Acoustics II (Vorlesung mit integrierten Übungen, 2 SWS)  
Müller G, Freisinger J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU43025: Vibroacoustics | Vibroakustik

Version of module description: Gültig ab winterterm 2019/20

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcomes of the Vibroacoustics module is confirmed by passing a 60 minute written examination at the end of the semester.

The aim of the examination of the Vibroacoustics module is the confirmation that the students have understood the basic concepts of signal processing and can describe the impact of dynamic loadings on buildings, highly sensitive devices and humans. They can concisely repeat their knowledge as well as applying it to tasks. The candidate must display the ability to describe and reflect upon the basic theories as well as analysing typical problems like assessing the impact of dynamic loadings on buildings, highly sensitive devices and humans, with the goal of discovering possible solution approaches while assessing their implementation feasibility.

No auxiliary means are allowed in the examination.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Basic knowledge in Structural Dynamics (such as BV430008)
- Basic knowledge in Technical Acoustics (such as BV000122)
- Basic knowledge in Integral Transform Methods (such as BV430002)

#### Content:

In this module basics of the application of structural dynamical and vibroacoustic calculations will be handled. Application examples are given by practical problems and models.

Also, the practical operation of measurement tasks (experiment set up, accumulation of data analysis of time line) are handled theoretically and carried out practically.

The thematic outline is as follows:

- Evaluation of vibrations (Perception through humans, comfort criteria, human induced oscillation)

- Excitation of structures by dynamic loads, e.g. machines or humans
- Methods of oscillation reduction
- Soil dynamics (Basics of wave propagation, Soil-Structure interaction, methods of oscillation reduction)
- Sensors and tools (accelerometers, microphones and laser vibrometers)
- Calibration, Checking, Measurement Uncertainty
- Signal Processing and Measurement Techniques (measurement chain setup, practical aspects of time-frequency analysis, time and frequency range filter)
- Experimental modal analysis
- Measurements and their analysis

### **Intended Learning Outcomes:**

After the successful completion of this module, the students understand

- dynamic loadings and their impact on buildings, highly sensitive devices and humans
- the basics of modelling of civil engineering constructions, as such modelling of building with regard to vibrational impact
- the effect of noise and vibrations to humans and are able to describe them
- the basic aspects of signal processing as well as the composition and function of the measurement chain elements

They can classify dynamic loads from different sources.

The students can apply the practical methods of structural dynamics and vibroacoustic measurement techniques to practical problems and assess the results.

### **Teaching and Learning Methods:**

The module consists of a lecture with integrated exercises.

The lecture part of the module helps to convey the aspects of structural dynamics, to show the relevance through application of the current themes as well as to present practical and research orientated examples from their field, motivating the student to involve themselves in the topic. The lecture notes are used actively in the course and are directly edited on the tablet PC, if necessary. This makes it possible to integrate discussions during the lecture into the course documentation. The exercise part of the module helps the students to apply the basics and concepts by solve real problem cases. Measurement tasks ranging from experiment set up to collection of data and analysis of the timelines will be carried out in small groups or as solo projects during the integrated exercises. Students are presented with the opportunity to independently (while supervised) apply the theoretical contents practically through planning, carrying out measurements and evaluating the results.

### **Media:**

As well as the lecture notes on tablet PC and digital projector, slides or lecture hall blackboard may be used. Exercise sheets and tasks may be published online as required. Measurements will be carried out on models and/or real buildings.



**Reading List:**

Müller, G, Möser, M.: Taschenbuch der Technischen Akustik, Springer, 2004

Petersen, C.: Dynamik der Baukonstruktionen, Vieweg, 2017

Cremer, L, Heckl, M.: Körperschall, Springer, 2010

Braun, S., Discover Signal Processing: An Interactive Guide for Engineers, Wiley 2008

Sujatha, C., Vibration And Acoustics: Measurement and Signal Analysis, Tata McGraw Hill Education 2010

**Responsible for Module:**

Prof. Dr.-Ing. Gerhard Müller

**Courses (Type of course, Weekly hours per semester), Instructor:**

Structural Dynamic Lab (Vorlesung mit integrierten Übungen, 4 SWS)

Lutzenberger S, Müller G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU43026: Modelling and Simulation in Structural Mechanics | Modellierung und Simulation in der Strukturdynamik

Version of module description: Gültig ab winterterm 2019/20

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam of the module is a project work consisting of a report and a presentation with subsequent discussion.

Participating in the project work, the students should prove that, working in a team of 2-3 students, they are able to apply theoretical knowledge in Structural Dynamics to specific tasks and to sum up the findings in a comprehensible and compact way in form of a report of 10-15 pages.

In the approximately 20-minute presentation at the end of the semester the students show that they can present the relevant findings using appropriate media in a comprehensible way. In the subsequent discussion they prove that they can defend their findings orally in front of an expert audience.

The presentation with subsequent discussion accounts for 60% of the exam. The report represents 40% of the exam. Both parts are done by the whole team, whereby every team member participates actively.

The tasks are of scientific nature and can reach from merely numerical implementations to product design and realization.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basic knowledge in Structural Dynamics (e.g. BV430008), object-oriented programming and the Finite Element Method

#### Content:

- Modal approaches for damped and undamped systems
- Harmonic and transient analysis of dynamic systems
- Root point excitation at non classically damped systems

- Methods for computer-aided description of wave propagation and damping
- Coupled problems (Soil-Structure-Interaction, Fluid-Structure-Interaction)
- Model Order Reduction

### **Intended Learning Outcomes:**

After successfully participating in the module, the students are able to understand complex approaches of Structural Dynamics, to apply them to given tasks and to present them in a comprehensible way.

The module provides a wide overview of advanced topics in Structural Dynamics and of their computer-aided implementation to the students. The students can classify different academically and practically relevant tasks and can identify appropriate solution strategies.

### **Teaching and Learning Methods:**

The module deals with advanced topics and computer-aided methods in Structural Dynamics. During the first few weeks of the semester, the topics are covered by introductory lectures and exercises. While theoretical basics are discussed during the lecture, the integrated exercises deal with their computer-aided implementation. Exemplary calculations are performed together with the students.

Subsequently, different topics for the project phase are proposed. Supervised by a tutor, the students work in small groups on a thematically closed task. The progress is monitored by means of a voluntary intermediate presentation in the middle of the project phase. In a subsequent feedback meeting the tutor helps the students to identify the strengths and deficits of their work. The project is closed by a presentation with subsequent discussion and by a report.

### **Media:**

The slides shown in lectures with integrated exercises are provided to the student via the platform Moodle. Furthermore, the students get access to the program code relevant for the exercises. Different topics are proposed to the student for the subsequent project phase. Templates for the presentation and the report are provided.

### **Reading List:**

E. Kausel, Advanced Structural Dynamics: Cambridge University Press, 2017.

A. K. Chopra, Dynamics of structures: Theory and applications to earthquake engineering, 4th ed. Harlow: Pearson Prentice Hall, 2014.

A. C. Antoulas, Approximation of large-scale dynamical systems. Philadelphia: SIAM, 2005.

### **Responsible for Module:**

Prof. Dr.-Ing. Gerhard Müller

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Modellierung und Simulation in der Strukturdynamik (Vorlesung mit integrierten Übungen, 2 SWS)  
Müller G, Schneider F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU44013T2: Computation in Engineering I | Computergestützte Berechnungsverfahren in den Ingenieurwissenschaften I

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a written exam (90 min) and a piece of work in the form of an exercise, with which the programming knowledge of the students is tested.

Within the scope of the study performance, the students present their exercise performance, a program for calculating a pipe network. With the independently completed programming task and the approx. 15 min. oral presentation of this, in which the individual program steps are explained, the students prove that they have understood the essential aspects of how to create a complex object-oriented program and that they are able to develop such a comprehensive program themselves. The exercise must be passed.

The exam should prove that the essential concepts of computer-aided calculation methods are understood in engineering. Among them the object-oriented modelling with conversion in C++, the mathematical bases for the representation of curves as well as the different methods for the modelling of geometrical objects in CAD systems. No aids are allowed in the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Prerequisite for a successful participation are basics of engineering informatics, which include the content of the modules 'Building and Environmental Informatics I (BGU65004)' and 'Building and Environmental Informatics II (BGU44011)'. In particular, it is necessary to master the basics of any programming language (data types, control structures, functions).

#### Content:

- object oriented modeling with Unified Modeling Language (UML)
- transferring UML to C++

- automatic and static objects, structures, classes, polymorphism, inheritance
- sets, relations and graphs
- principles of geometric modeling
- direct and indirect representation schemes
- Space trees such as octrees
- vertex-edge-face(vef)-graphs, efficient data structures
- winged-edge data structure for BoundaryRepresentation-models
- Euler-operators
- geometrical and mathematical representation of curves
- approximation of points with the method of least squares
- implementation schemes in two dimensions
- cubic splines
- Bezier-curves
- B-splines

### **Intended Learning Outcomes:**

After the participation in the module, the students are able to:

- describe and implement technical processes algorithmically
- develop object-oriented software of moderate complexity in C++
- to assess the advantages and disadvantages of the methods used in CAD systems to model three-dimensional geometric objects (BRep, CSG, octal trees)
- to apply the mathematical basics of the splines and B-splines frequently used in computer-aided geometry for the representation of curves

### **Teaching and Learning Methods:**

The module consists of a lecture and an accompanying central exercise. In the exercise, the methods developed in the lecture are implemented in C++. The necessary programming techniques are taught in the lecture. Some tasks to assess the learning progress, will be programmed in the lecture after the taught material. The solutions will be presented and discussed in the following week.

The lecture and the exercise take place in the computer rooms of the faculty, so that own notes can be inserted immediately into the on-line available lecture material and the exercise material can be converted at own program examples. All presentation documents, tasks, solutions etc. can be downloaded from the website with the handwritten supplements of the respective lecturer (tablet PC) after the respective course to support self-study.

### **Media:**

PowerPoint as well as the white board

### **Reading List:**

Daoqi Yang: C++ and object-oriented numeric computing for Scientists and Engineers, Springer-Verlag 2001. A sufficient number of copies is in stock at the university library. Additionally, print out copies of the manuscript and lecture notes are available from the lecturer.

**Responsible for Module:**

PD Dr.-Ing. habil. Stefan Kollmannsberger

**Courses (Type of course, Weekly hours per semester), Instructor:**

Computergestützte Berechnungsverfahren in den Ingenieurwissenschaften I (Vorlesung, 2 SWS)

Kollmannsberger S

Übung zu Computergestützte Berechnungsverfahren in den Ingenieurwissenschaften I (Übung, 1 SWS)

Kopp P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU45037: Introduction to Earth System Science | Einführung in die Erdsystemforschung

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>90   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The expected learning outcomes are verified with a written exam of 120 min duration, which might also contain short mathematical problems to be solved. In the written exam, the students should verify, by answering theoretical and numerical questions, that they are able to understand the basic components of system Earth and its main geodynamic processes in the Earth interior, at the surface, and the global energy budget. A written exam is required in order to check if students are able to apply the Earth system concepts to practical problems as well as to perform corresponding numerical analyses. By means of numerical tasks and problems, it is verified that students are able to apply the mathematical and physical concepts for the solution of practical problems. By means of selected tasks, the students are able to interpret geophysical, geodetic and geodynamical results and to put them into the scope of geoscientific concepts.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Knowledge of fundamentals in mathematical physics, linear algebra, time series analysis.

**Content:**

The module consists of one lecture "Introduction to Earth System Science". It is split up into two main topics: part A "Outer System" and part B "Inner System" and is connecting earth's interior and earth's surface up to Earth's orbits.

**Part A: Outer System:**

- components of the Earth System (atmosphere, ocean, cryosphere, solid Earth),
- electromagnetic radiation and matter,
- solar radiation and the Earth system,
- radiation balance, greenhouse effect,
- spatial and temporal variations, astronomical rhythms (day/night, seasons, Milankovitch cycle),
- atmospheric circulation,
- oceans
- continental hydrology
- cryosphere
- the role of satellites (active and passive sensors)

**Part B: Inner System:**

- dynamics of the earth interior,
- heat exchange,
- mantle convection,
- analysis of seismic wave propagation,
- potential fields: magnetic field, gravity field;
- measuring solid Earth processes with satellites (GPS, gravimetry, magnetometry, topography)
- interaction of inner and outer part of the earth system

**Intended Learning Outcomes:**

Upon successful completion of the module, students are able

- to understand the fundamental principles of the complex Earth system, its main geodynamic processes in the interior and on the surface, as well as their coupling mechanisms,
- to understand the global energy budget,
- to understand the role of satellite observations for the monitoring of geodynamic processes in the Earth system,
- to work with observations, data and models of selected components of the Earth system,
- to apply the mathematical and physical concepts concerning selected components of the Earth system,
- to analyze the results of these data and models,
- to understand these scientific contributions as integral component of geodetic Earth system research,
- to communicate on a scientific level with experts of different geoscientific disciplines.

**Teaching and Learning Methods:**

The contents of the lectures are communicated by oral presentations or calculations at the blackboard, including interactive discussions with the students.



**Media:**

- Blackboard
- Lecture notes
- Presentations in electronic form

**Reading List:**

- Kandel, Robert S. (1980): Earth and Cosmos. A Book Relating the Environment of Man on Earth to the Environment of Earth in the Cosmos. Burlington: Elsevier Scienc
- Grotzinger, John; Jordan, Thomas H.; Press, Frank; Siever, Raymond (2007): Understanding earth. 5. ed. New York: Freeman
- Lowrie, William (2006): Fundamentals of geophysics. 7. print. Cambridge: Cambridge Univ. Press

**Responsible for Module:**

Roland Pail

**Courses (Type of course, Weekly hours per semester), Instructor:**

Introduction to Earth System Science (Vorlesung, 4 SWS)

Pail R [L], Pail R, Schuberth B, Abrykov P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46029: Summer School of NeXus Water Food Energy | Summer School zum NeXus Water Food Energy

Version of module description: Gültig ab summerterm 2014

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>5          | <b>Total Hours:</b><br>150  | <b>Self-study Hours:</b><br>50   | <b>Contact Hours:</b><br>100         |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

Example topics include: Pesticide pertinence, water treatment, erosion and contamination from diffusive sources, Water resources management, hydrology and climate, land use and urban growth dynamics, biodiversity and restoration of aquatic ecosystems and responsibility to resources in the Nexus context. The summer school takes place in the Oskar-von-Miller Institut near Garmisch-Partenkirchen and at TUM City Campus.

The scientific format of the summer school includes both keynote talks and lectures by leading experts in the fields of life and water sciences from our partner universities and TUM, as well as project presentations by students and discussion groups. The summer school is also meant to increase the scientific collaboration and student exchange between all our partner universities and TUM.

#### Intended Learning Outcomes:

#### Teaching and Learning Methods:

**Media:**

**Reading List:**

**Responsible for Module:**

Franz Zunic (franz.zunic@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU60015: Reliability for Engineering Systems | Zuverlässigkeit von Systemen

*Reliability of engineering systems*

Version of module description: Gültig ab summerterm 2016

|                       |                             |                                  |                                      |
|-----------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b>  | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3 | <b>Total Hours:</b><br>120  | <b>Self-study Hours:</b><br>80   | <b>Contact Hours:</b><br>40          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In the oral examination the student should be able to reflect and reproduce the contents of the course. The student will be given one problem that is oriented at the lectures as well as the homework and exercises throughout the semester. The student should study the problem and outline a solution during 15 minutes. Subsequently he/she will present his/her solution and answer follow-up questions. The students have to be able to describe and reflect important theories. Solutions will be discussed and examined during iterative rounds of questions. The oral examination enables the examiners to be responsive to the individual student and to evaluate the student's competences realistically.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Risk Analysis 1

#### Content:

1. General introduction and brief review of course prerequisites
2. Binary system models
3. Fault tree and event tree analysis
4. Dependent failures
5. Physically-based system models
6. Sampling-based system reliability
7. Performance and sensitivity measures

**Intended Learning Outcomes:**

This course enables the student to analyze, manage and communicate the reliability of infrastructure, technical and environmental systems. Upon completion of the course, students will be able to:

- Select appropriate system models for reliability assessment.
- Utilize traditional tools for system reliability and risk analysis, such as fault and event trees.
- Model complex engineering systems through sampling based methods.
- Compute system failure probabilities
- Model and assess the effect of dependence among system components
- Identify important components and failure modes in systems.
- Implement the methods in computational tools such as Matlab

**Teaching and Learning Methods:**

The course will consist of lectures, including application examples, and exercises from the fields of civil, environmental, structural and transportation engineering.

Lectures will be given on the blackboard and through slides. Case studies should help the understanding of the problems. The lecture notes in PDF form will be distributed at the beginning of the semester.

Homework will be provided but is not compulsory.

**Media:**

- Lectures with blackboard supported by slides
- Supervised study
- Lecture notes including theory and examples
- Optional homework examples

**Reading List:**

Bedford, T., and Cooke, R. (2001). Probabilistic risk analysis: foundations and methods, Cambridge University Press.

**Responsible for Module:**

Prof. Daniel Straub [straub@tum.de](mailto:straub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Zuverlässigkeit von Systemen (Vorlesung, 2 SWS)

Straub D, Teichgräber P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU60018: Estimation of Rare Events and Failure Probabilities | Abschätzung von seltenen Ereignissen und Versagenswahrscheinlichkeiten

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The course assessment takes place as a project work. The students will solve a practical problem that requires implementation of the methods discussed in class in a computer code. The students will be evaluated based on a written project report that documents the implemented approach and obtained results. The students will present their project in a 15-minute presentation followed by a discussion of the presented solution approach. The aim of the project is that students become familiar with the concepts discussed in class through hands-on experience. The project report will assess the students' understanding of the implemented methods and their applicability to specific problems. The purpose of the presentation is to assess the students' ability to describe theoretical concepts and communicate the adopted approach to solve a practical problem in a clear fashion.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Risk Analysis/Stochastic Finite Element Methods

The course will assume a basic knowledge of probability concepts such as random variables and their

description (e.g., through completion of the MSc course “Risk Analysis” or “Stochastic Finite Element Methods”). Basic knowledge of Matlab or Python is required for the exercises.

**Content:**

The course introduces shortly probability theory. Then all state of the art methods to calculate the probability of rare events are introduced.

1. General introduction
2. Random variables/Random vectors
3. Rare events and reliability problems
4. Approximate reliability analysis
5. Simulation of random variables
  - 5(a). Pseudo-random sampling
  - 5(b). Rejection sampling
  - 5(c). Markov chain Monte Carlo methods
6. Simulation of rare events
  - 6(a). Monte Carlo simulation
  - 6(b). Importance sampling
  - 6(c). Cross-entropy method
7. Simulation in high dimensions
  - 7(a). Screening method
  - 7(b). Subset simulation
8. Bayesian analysis of rare events

**Intended Learning Outcomes:**

This course enables the students to understand and implement state-of-the-art methods for estimating

probabilities of rare events. In the end of the semester the students will be able to:

- Generate random samples from arbitrary distributions
- Apply approximations to rare events and reliability problems
- Estimate efficiently rare event probabilities with sampling methods
- Estimate rare event probabilities in problems with large number of random variables
  
- Update rare event probabilities with observations
- Implement advanced simulation methods in computational tools such as Python or Matlab

**Teaching and Learning Methods:**

The course consists of weekly lectures. Lectures will be given partly on the black/whiteboard and partly by presentations on slides. The whiteboard allows to derive theoretical concepts and mathematical formulations at a pace that is conducive to a deeper understanding. The presentations

on slides facilitates graphical illustration of the new concepts and enables to make complex content more comprehensible.

Homework exercises will be given and their solutions will be posted in moodle. A selection of the homework exercises will be discussed in class. Some of the exercises will require the use of suitable software tools, such as Matlab or Python. Homework exercises facilitate understanding of the taught methods and their applicability to different problems.

**Media:**

- Lectures with blackboard supported by slides
- Exercise sheets
- Matlab code examples

**Reading List:**

References and selected materials will be provided

**Responsible for Module:**

Max Teichgräber

**Courses (Type of course, Weekly hours per semester), Instructor:**

Estimation of rare events and failure probabilities (Vorlesung mit integrierten Übungen, 3 SWS)

Ehre M, Papaioannou I

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU60019: Stochastic Finite Element Methods | Stochastische Finite Elemente Methode [SFEM]

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

A take-home exercise sheet and will be given after the first half of the course. The purpose of the exercise sheet is to assess the students understanding of the basic concepts of probability theory discussed in the first part of the course. The content will be closely related to the exercises and theoretical concepts discussed in class. The final exam will be oral. The students will be asked to solve simple exercises that reflect the practical topics discussed in the lecture. The purpose is to assess the ability of the students to understand the basic principles of stochastic finite element methods and to apply these methods for analyzing the impact of uncertainties on physical systems. The students will be given 30min to prepare for the exam; the exam duration will be 25min. The final grade will be based on the final exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The course will assume basic knowledge of the linear finite element method for the solution of one-dimensional linear elasticity problems.

Basic knowledge of probability theory is recommended, but not required. Basic knowledge of Matlab is an advantage.

#### Content:

This lecture is an introduction to the basic concepts of stochastic finite element methods for the uncertainty quantification of elastostatic systems. The course covers the following contents:

1. Introduction to probability theory and stochastic calculus
- 1(a). Random variables

- 1(b). Random vectors
- 2. Functions of random variables
  - 2(a). Estimation of moments of functions
  - 2(b). Probabilistic transformation
  - 2(c). The Monte Carlo method
- 3. Random fields
  - 3(a). Discretization of random fields
  - 3(b). Reduction of stochastic dimension by spectral decomposition
  - 3(c). The Karhunen-Loève expansion
- 4. Finite elements with random inputs
  - 4(a). The linear elastostatic problem and its solution by the finite element method
  - 4(b). Stochastic stiffness matrix and force vector
  - 4(c). Monte Carlo method, Perturbation method
- 5. Advanced Monte Carlo methods
  - 5(a). Advanced sampling methods
  - 5(b). Multi-level Monte Carlo method
- 6. Spectral stochastic finite elements
  - 6(a). Polynomial chaos expansion
  - 6(b). Stochastic Galerkin method
  - 6(c). Stochastic collocation methods

#### **Intended Learning Outcomes:**

This course enables the students to understand and implement numerical methods for analyzing physical systems with uncertain input parameters. In the end of the semester the students will be able to:

- Understand the basic concepts of probability theory
- Define random vectors and random fields based on their second moment properties
- Discretize random fields into a finite number of random variables
- Assess the applicability of different stochastic discretization methods based on specific problem settings
- Apply Monte Carlo methods for solving uncertain finite element systems
- Apply spectral stochastic finite element methods with various algorithmic settings

#### **Teaching and Learning Methods:**

The course consists of weekly lectures. Lectures will be given partly on the black/whiteboard and partly by presentations on slides. The whiteboard allows to derive theoretical concepts and mathematical formulations at a pace that is conducive to a deeper understanding. The presentations on slides facilitates graphical illustration of the new concepts and enables to make complex content more comprehensible.

Homework exercises will be given and their solutions will be posted in moodle. A selection of the homework exercises will be discussed in class. Some of the exercises will require the use of suitable software tools, such as Matlab or Python. Homework exercises facilitate understanding of the taught methods and their applicability to different problems.

**Media:**

- Lectures with blackboard supported by slides
- Exercise sheets
- Matlab code examples

**Reading List:**

A script will be distributed in electronic form. For further reading, the following are recommended:

- Kleiber, M, Hien, TD. The stochastic finite element method. Basic perturbation and computer implementation. New York: Wiley; 1992
- Ghanem, RG, Spanos, PD. Stochastic finite elements: A spectral approach. New York: Springer; 1991 (reissued by Dover Publications; 2004)
- Sudret, B, Der Kiureghian, A. Stochastic finite elements and reliability: A state-of-the-art report. University of California, Berkeley, Technical Report no UCB/SEMM-2000/08; 2000
- Xiu, D. Numerical methods for stochastic computations: A spectral method approach. Princeton: Princeton University Press; 2010
- Cliffe, KA, Giles, MB, Scheichl, R, Teckentrup, AL. Multilevel Monte Carlo methods and applications to elliptic PDEs with random coefficients. Comput Visual Sci (2011) 14:3-15

**Responsible for Module:**

Dr. Iason Papaioannou [iason.papaioannou@tum.de](mailto:iason.papaioannou@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Stochastic Finite Element Methods (Vorlesung, 4 SWS)

Papaioannou I [L], Chan J, Papaioannou I

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU60021: Risk Assessment and Reliability of Engineering Systems | Risikobewertung und Systemzuverlässigkeit [RA&SR]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

There will be a oral exam of 40 minutes duration at the end of the semester. It will be an open book exam, thus notes and aids are allowed. The student should study the problem and outline a solution during the first 20 minutes. In the subsequent 20 minutes he/she will present his/her solution and answer follow-up questions. Solutions will be discussed and examined during iterative rounds of questions. The oral examination enables the examiners to be responsive to the individual student and to evaluate the student's competences realistically.

The problems to be solved in the exam are based on the lecture contents and the exercises of the semester. The students need to be able 1) to explain main concepts in their own words and 2) to solve arithmetical problems. The students are supposed to show if and up to what extent they have understood the principles and concepts of the theory of probability and if they are able to apply these concepts to problems in the field of engineering.

The student can submit an assignment during the semester. Successful completion gives a bonus of 0.3 for the final grade.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Risk Analysis

#### Content:

Part Risk Assessment:

1. General introduction
2. Bayesian networks

3. Utility theory
4. Decision analysis
5. Life-cycle analysis and cost-benefit analysis
6. Risk acceptance
7. Risk management

**Part System Reliability:**

1. General introduction
2. Time-dependent reliability
3. Binary system models
4. Fault tree and event tree analysis
5. Dependent failures
6. Physically-based system models
7. Sampling-based system reliability
8. Performance and sensitivity measures

**Intended Learning Outcomes:**

This course enables the student to analyze, manage and communicate the reliability of and risks in civil systems and environment. Upon completion of the module, students will be able to:

- Understand reliability, risk, utility, and, decisions.
- Understand traditional tools for system reliability and risk analysis, such as fault, event and decision trees.
- Select appropriate system models for reliability assessment.
- Model complex engineering systems and decisions under uncertainty
- Identify important components and failure modes in systems.
- Assess risk acceptance criteria.
- Plan risk management for engineering systems.
- Model complex engineering systems through sampling and simulation based methods.
- Implement the methods in computational tools such as Matlab

**Teaching and Learning Methods:**

The course consists of lectures, including application examples, and exercises from the fields of civil, environmental, structural, mechanical and transportation engineering.

Lectures will be given on the black/whiteboard, including selected illustrations. Case studies should help the understanding of the problems. The lecture notes in PDF form will be distributed at the beginning of the semester.

Homework, accompanying the lectures, will be provided.

**Media:**

- Lectures with blackboard supported by slides
- Lecture notes including theory and examples
- Optional homework examples

**Reading List:**

Lecture notes and selected papers will be distributed.

**Responsible for Module:**

Herr Prof. Dr. sc. Tech. Daniel Straub [straub@tum.de](mailto:straub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Risikobewertung (Vorlesung, 3 SWS)

Straub D, Teichgräber P

Zuverlässigkeit von Systemen (Vorlesung, 2 SWS)

Straub D, Teichgräber P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU62059: Application of an Life Cycle Assessment for Civil Engineering | Anwendung einer Lebenszyklusanalyse für Bauingenieurwesen

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of a scientific paper including a short presentation.

In the wiss. (30-40 pages) the students show whether they are able to reproduce a concrete application of a life cycle analysis (LCA) on an existing or planned building in a scientifically correct way. The aim of the paper is to examine to what extent a know. The elaboration aims at checking to what extent a scientific analysis of the task is carried out under the aspects of the application of target-oriented scientific methods. The concrete application of a life cycle analysis (LCA) to a building is based on an example project.

In a short presentation (approx. 10 min.) the students show that they are able to rhetorically reproduce the facts and that they are able to engage in a dialogue with the audience on the topic. The examination performance takes place online: the scientific paper is uploaded via Moodle and the presentations take place via ZOOM.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The successful participation in the module LCA BV360009

#### Content:

The content of the module Application of a Life Cycle Analysis (LCA) consists of

- Teaching the basics of a building LCA
- Mediation of software knowledge for the implementation of a LCA
- Calculation and evaluation of energy and CO<sub>2</sub> balances at material and component level
- Identification of potentials for reducing environmental impacts

- Students work independently on a given project
- Presentation of the elaborated results in a lecture and elaboration of a seminar paper

### **Intended Learning Outcomes:**

After participating in the module, the students are able to

- reflect a sound basic understanding of life cycle assessment
- to adequately evaluate the results of the life cycle assessment.
- to analyse energy and CO<sub>2</sub> balances.
- To understand the most important ecological parameters of a building.
- to apply calculations in a life cycle assessment software (eLCA) to specific buildings.
- to analyse existing building structures with regard to the components and materials used over all life cycle phases and to develop optimisation proposals
- Develop recommendations for ecological optimisation of a building design, taking into account all life cycle phases.
- to reflect a life cycle analysis on a building in a scientifically correct way.

### **Teaching and Learning Methods:**

The module consists of one seminar. In the seminar there are individual input lectures to give the students the necessary basics about life cycle assessment and life cycle analysis. Based on the lectures, the application of this knowledge takes place in the seminar using a concrete example project. The students work on the tasks in groups and are supervised by the teacher (group work, seminar). The participants develop sustainable building components and identify the associated effects on the building and the environment, focusing on the application of a life-cycle approach to the concrete building and understanding the most important adjustment screws. It is particularly important to develop and answer ecological questions in early planning phases on a project-specific basis.

### **Media:**

Power Point, eLCA

### **Reading List:**

DIN, ENISO. 14044: 2006-10 Umweltmanagement–Ökobilanz–Anforderungen und Anleitungen. DIN Deutsches Institut für Normung eV Berlin: Beuth Verlag, 2006. DIN, ENISO. 14040: Umweltmanagement–Ökobilanz–Prinzipien und allgemeine Anforderungen. Deutsche Fassung der EN ISO, 1997, 14040. Jg., Nr. 1997, S. 16. KÖNIG, Holger, et al. Lebenszyklusanalyse in der Gebäudeplanung. Institut für internationale Architektur-Dokumentation, München, 2009.

### **Responsible for Module:**

Prof. Dr.-Ing. Werner Lang sekretariat.enpb.bgu@tum.de

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Anwendung einer Lebenszyklusanalyse (Seminar, 4 SWS)

Lang W [L], Schwering K, Takser I, Theilig K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU65006: Professional Software Development | Professionelle Softwareentwicklung [ProSD]

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>4          | <b>Total Hours:</b><br>120  | <b>Self-study Hours:</b><br>75   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination consists of 7 exercises. The assignments are distributed over the semester and are used to test the theoretical and practical knowledge in software development achieved by the students during the course. Five assignments are programming practices, the others two are short exams. All exercises are weighted evenly.

The programming practices are used to consolidate the learned subjects and will provide hands-on-practice. The students will form groups and experience the meaning of software development in teams. For solving the practical assignments, the students will have at least 10 days and can use any resource available. Source code, not written by themselves or their team members, must be highlighted and cited correctly. In addition to the source code, five minute oral interviews will take place to identify the individual contribution to the source.

The short exams are used to test the theoretical knowledge of the students. Following topics will be part of these exams: object orientation, SOLID principles, data interactions. Allowed tools for the exams are drawing instruments and a two-sided handwritten sheet of A4 paper.

The composition of exercises of professional software development in practice, i.e. computer-oriented methods and object-oriented programming language allow to test the students systematically and still monitor each student as an individual.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Fundamental programming skills are required.

#### Content:

- Getting familiar with professional software development on the basis of a high level programming language

- Object-oriented design based on the Unified Modeling Language
- High level object-oriented programming concepts: SOLID, inheritance, Interfaces, Dependency Injection
- Design Patterns
- Team-Work with the aid of: Repositories, Unit testing, Documentation
- Parallel Systems: communication processes, protocols and threading

**Intended Learning Outcomes:**

After completion of the module the students will have knowledge of high level programming languages (Object-orientation, inheritance, Interfaces, Exceptions, Code Contracts, dependency injection, Threads, Patterns), and concepts and methods of software development in teams (Repositories, Unit Testing, Documentation) together with skills in designing and using data-exchange interfaces in the context of engineering. Furthermore, they understand the basic concepts of parallel architectures.

**Teaching and Learning Methods:**

The teaching results of the module are achieved by multiple coordinated components. The lectures are supported by PowerPoint presentations, blackboard scripts and movies illustrating computer simulations. While the assignments must be solved outside of the lecture, the students are supported in individual sessions.

**Media:**

Lectures and exercises: PowerPoint presentations, blackboard script and software examples on the computer.

**Reading List:**

Lecture notes with extensive references.

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Professional Software Development (Vorlesung, 3 SWS)

Dubey R, Pfitzner F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU65009: Artificial Intelligence in Engineering | Künstliche Intelligenz im Ingenieurwesen [AI]

Version of module description: Gültig ab summerterm 2016

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcome is confirmed by passing a 90 minute written examination. The aim of the examination is confirmation that the theoretical key concepts of machine learning, localization filters and expert systems have been understood and can be concisely recalled. Furthermore, small application tasks will assess the students ability to apply the acquired learning outcomes. In the examination no auxiliary means are allowed.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Fundamental programming skills

#### Content:

- Localization Filters  
(Such as Bayesian filter, Kalman filter, particle filter)
- Machine learning algorithms  
(Such as linear neural networks, Kohonen maps, reinforcement learning)
- Expert systems  
(First order predicate logic & Inferenzregeln)
- Robotik  
(Mit realen Sensordaten und Aktoren, praktische Anwendung von Lokalisierungsfiltern)
- Anwendungsfälle künstlicher Intelligenz in Ingenieursanwendungen

#### Intended Learning Outcomes:

After participation in the module the students have acquired a deepened understanding of the basic techniques in artificial intelligence and its application for engineering problems. Moreover,

students are able to predict, assess and subsequently develop solution approaches for problems stemming from real-life application of artificial intelligence.

**Teaching and Learning Methods:**

The lectures will use power point slides and will be split into the different topics. For each topic the connection to the fundamental origins (such as neural networks in human brains) will be presented as well as its connection to the engineering domain. The students will learn to apply their knowledge on a practical localization problem using the available robot kits. The robot assignment will be performed in small teams of students.

**Media:**

Powerpoint, Software on private Laptop

**Reading List:**

Russell, S., Norvig, P., Canny, J., Malik, J., & Edwards, D. (1995). Artificial Intelligence: A Modern Approach. Prentice hall Englewood Cliffs.

Krishnamoorthy, C. S., & Rajeev, S. (1996). Artificial Intelligence and Expert Systems for Engineers. CRC Press LLC.

**Responsible for Module:**

Andr  Borrmann (andre.borrmann@tum.de) Modulbeauftragter: Christoph Ertl (christoph.ertl@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Artificial Intelligence in Engineering (Vorlesung, 2 SWS)

B gler M, Collins F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BGU68002: Research Design: How to tackle a Master's Thesis | Wissenschaftstheorie: Bewältigen einer Master Thesis [Research Design]**

*Research Design: How to tackle a Master's Thesis*

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>45   | <b>Self-study Hours:</b>         | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

Term paper

#### **Repeat Examination:**

End of Semester

#### **(Recommended) Prerequisites:**

Completed 3 semesters of transport systems master program.

#### **Content:**

The purpose of the course is to help you design, conduct, publish, defend, and present quality research in engineering fields. Because research in engineering includes many diverse subfields, research design varies widely. Therefore, we will address a range of topics that will help you refine (and in some cases broaden) your research approach.

#### **Intended Learning Outcomes:**

Course objectives:

- Understand principles of scientific inquiry and scientific methods.
- Assemble, organize, and summarize a well-defined body of literature.
- Write a sound and coherent research proposal.
- Defend your topic in a presentation.
- Review, design, and conduct quantitative and qualitative research.
- Review, design, and conduct case study and survey research.
- Prepare yourself to present a paper at an academic conference.
- Review an article submitted for publication in an academic journal.
- Find potential sources of research funding.

**Teaching and Learning Methods:**

This is not a traditional top-down lecture, but students are expected to actively engage with the materials. Readings will be provided, which students are asked to work through before class. Students also need to submit a literature review on her or his respective topic to show the ability to condense work previously published into a solid review. Last but not least, students will be asked to prepare short presentations on selected topics.

**Media:****Reading List:****Responsible for Module:**

Moeckel, Rolf; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Research Design: How to tackle a Master's Thesis (Seminar, 3 SWS)

Moeckel R [L], Moeckel R

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV000063: System-Theoretical Principles of Project Management | Systemtheoretische Grundlagen des Projektmanagements [GL\_PM]**

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                                |
|--------------------------------|-----------------------------|----------------------------------|------------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer<br>semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30                    |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The elaboration of a respective project by a team of students proves not only their understanding of the learning content but also their ability to apply the methods, evaluate the results and consequences and moreover to develop the given approaches for further fields of utilization.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Fundamentals of Process-oriented Planning and Organisation (GPPO BGU 55027)

Higher Mathematics

#### **Content:**

Projects and environment, fundamental definitions, 2nd order management, theory of systems, fundamental mechanisms of coordination, Cross-Impact-Analysis;

Factors of success, function, identification and interactions;

Process-oriented organisation of projects, models of proceeding, organisation structures and complexity;

Cost and resources in complex environments, cost-estimations and separability, expert knowledge, monitoring of cost;

Scheduling duration and target dates, theory of graphs, causal network plans, fuzzy networks, recent developments.

#### **Intended Learning Outcomes:**

Having successfully completed the module the students will have understood the given learning content and will be able to apply and develop this further. Therewith, they know to analyze and evaluate applicable situations and solve respective problems when later professionally working

**Teaching and Learning Methods:**

The learning content is taught via lectures. Supervised exercises and tutorials allow deepening this with the help of examples in interaction with the students.

**Media:**

Lecture notes, power point-presentations, partially use of black/whiteboard, videoclip

**Reading List:**

Detailed lecture notes

**Responsible for Module:**

Dr. Wolfgang Eber (eb@bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Systemtheoretische Grundlagen des Projektmanagements / System-Theoretical Principles of Project Management (Vorlesung, 2 SWS)

Eber W

Systemtheoretische Grundlagen des Projektmanagements / System-Theoretical Principles of Project Management (Vorlesung, 2 SWS)

Eber W [L], Eber W

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BV000122: Introduction into Technical Acoustics | Einführung in die Technische Akustik

Version of module description: Gültig ab summerterm 2019

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcome of the Introduction into Technical Acoustics module is confirmed by passing a 60 minute written examination at the end of the semester.

The aim of the examination is the confirmation that the key acoustic concepts which relate to complex quantities and Fourier Transformations have been understood and can be concisely recalled and implemented. For example the student should be able to understand, repeat and apply the basics about the origins, perception and weighting of sound as well as the prediction of sound fields as a result of different sound sources. Furthermore, problems must be analyzed and solution approaches found within a limited time using the learning outcomes achieved during the module.

The solutions sometimes require the student's own interpretation, in part selection of single or multiple choice answers, whereby the emphasis is on short calculation exercises.

A non-programmable calculator is allowed in the exam.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Basic knowledge in Structural Dynamics
- Basic knowledge in Logarithm Calculus and calculating with Complex Numbers

#### Content:

In this module the fundamental basics of Technical Acoustics are handled.

The thematic outline is as follows:

- Transformation methods Time-Frequency domain
- Calculation with complex variables
- Perception of sound (Law of Weber Fechner, calculation with sound level and effective values, Frequency dependent perception and their standards, time dependent sound levels)
- Prediction of sound fields (Superposition of coherent/incoherent sound sources, wave propagation in two and three dimensions, sound velocity, intensity and power)
- Sound radiation (Sound source types, plate radiation, structure borne sound, coincidence cut off frequency)

### **Intended Learning Outcomes:**

After participating in this lecture students are able to understand the basics of Technical Acoustics. Applying their knowledge of complex numbers and logarithm calculus, they are able to calculate sound levels and characterize sound fields. Furthermore, students can evaluate, using fundamental physical principles, the mechanisms of sound radiation, their characteristics, and the measures employed to influence them.

### **Teaching and Learning Methods:**

The module comprises of a lecture which is held with the help of a tablet PC as well as a digital projector. The lecturer is hereby able to clearly convey the fundamental aspects of Technical Acoustics, show the relevance through application of the current themes as well as present practical and research orientated example from their field, motivating the student to involve themselves in the topic. The lecturers work with notes to which additions can be made with a tablet PC, allowing discussions during the lecture to be integrated into the course documentation. On top of lectures, seminars are offered which should help the student to apply the basics and concepts to real problem cases. Students will be supplied with calculation exercise sheets to help deepen their understanding and practical application.

### **Media:**

As well as the lecture notes on tablet PC and digital projector, slides or lecture hall blackboard may be used. Exercise sheets are published online. Audio samples will be used selectively to illustrate the contents. Prepared measurements of acoustic criteria will be implemented at appropriate stages. A field trip will be, if possible, organized to a technical acoustic consultancy firm.

### **Reading List:**

Müller, Gerhard ; Möser, Michael: Taschenbuch der Technischen Akustik, Springer  
Müller, Gerhard ; Möser, Michael: Handbook of Engineering Acoustics, Springer  
Möser, Michael: Technische Akustik, Springer

### **Responsible for Module:**

Prof. Dr.-Ing. Gerhard Müller

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Technical Acoustics 1 (Vorlesung mit integrierten Übungen, 2 SWS)

Müller G, Freisinger J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV020007: Boundary Element Method | Randelementmethode

Version of module description: Gültig ab summerterm 2018

|                                |                             |                                  |                             |
|--------------------------------|-----------------------------|----------------------------------|-----------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b>           |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcomes of the Boundary Element Method module will be assessed in a 60 minute written examination.

The aim of the examination is confirmation that the fundamental idea of the method, the necessary mathematical method of solution as well as the application of the method to practical questions have been understood and can be concisely recalled and implemented. Furthermore, problems must be analyzed and solution approaches found within a limited time using the learning outcomes achieved during the module.

The solutions require the student's own interpretation.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Knowledge of Technical Mechanics and Structural Dynamics
- Basics of differential and numerical mathematics.

#### Content:

The fundamental basics of the Boundary Element Method are handled in this module.

The thematic outline is as follows:

- System description using differential equations
- Approximate solutions (weighted residual, Galerkin, Collocation, Ritz)
- Theoretical discourse of Boundary Element Method
- Application of the Boundary Element Method to Fluids

- Boundary Element Method to describe dynamic processes and application in acoustics and layered media (soil)

**Intended Learning Outcomes:**

After successful participation in the module Boundary Element Method, students are able to classify differential equations based on their structure. With the help of the approximation approaches learned in this course the students can evaluate different solutions for systems and the Boundary Element Method can be applied to different structures.

**Teaching and Learning Methods:**

The module comprises of a lecture which is held with the help of a tablet PC as well as a digital projector. The lecturer is hereby able to clearly convey the fundamental aspects of the Boundary Element Method, show the relevance through application of the current themes as well as present practical and research orientated example from their field, motivating the student to involve themselves in the topic. The lecturers work with notes to which additions can be made with a tablet PC, allowing discussions during the lecture to be integrated into the course documentation. On top of lectures, exercises are offered which should help the student to apply the basics and concepts to real problem cases. With help of computer seminars, calculation methods can be practiced which would be too extensive to calculate per hand. These seminars can be completed alone or in a group. Students will be supplied with calculation exercise sheets as required to help deepen their understanding and practical application.

**Media:**

As well as the lecture notes on tablet PC and digital projector, slides or lecture hall blackboard may be used. Exercise sheets and tasks may be published online as required.

**Reading List:**

Brebbia, C.A., Walker, S.: Boundary-Element-Techniques in Engineering, Newnes-Butterworth 1980  
Beskos, D.E.: Boundary Element Methods in Dynamic Analysis, Appl. Mech. Rev. Vol 40, No. 1 1987, pp1-23  
Gaul L., Fiedler C.: Methode der Randelemente in Statik und Dynamik, Vieweg 1997  
Hartmann, F.: Methode der Randelemente, Springer 1987  
Gaul L., Kogl M., Wagner M.: Boundary Element Methods for Engineers and Scientists, Springer 2003

**Responsible for Module:**

Prof. Dr.-Ing. Gerhard Müller

**Courses (Type of course, Weekly hours per semester), Instructor:**

Boundary Element Methods (BEM) (Vorlesung, 2 SWS)

Waubke H, Freisinger J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV030004: Software Lab | Software Lab

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>150   | <b>Contact Hours:</b><br>30                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a project work in a team, including the presentation of the project work. The topics of the project work are distributed according to the students' preferences and are based on current problems in industry and research and are worked on independently by the students.

The project includes the familiarization with the problem, if necessary a literature research, the choice and implementation of the solution approach in a software product. Partly the software implementation includes the familiarization with already developed software modules or the connection to commercial software products.

The module grade consists of the evaluation of two intermediate presentations, a final presentation a scientific poster, the source code of the developed software as well as its written documentation and the evaluation of the ability to work in a team in the supervised meetings. The progress of the work is documented in two presentations in which the students present their results in groups. In addition, the quality of the poster will be evaluated in a final presentation at the end of the project period, in which the poster will also be presented. Finally, the software projects and the documentation will be evaluated. The weighting of the individual sub-grades is 10% for each intermediate presentation 10% for the final presentation, 10% for the poster and the documentation of the source code, 50% from the developed software, and 10% for the ability to work in a team.

With the help of the presentations, it should be demonstrated that the students have understood the theoretical concepts underlying their project and are able to apply and evaluate these concepts in a structured way to the problem at hand (problem-solving skills). Furthermore, the students should present the progress at the beginning, middle and end of your project and thus show additional competences in presentation techniques. Checking the progress during the

presentations motivates the methodical "soft" competences of software development in several phases (e.g. agile methods).

The final presentation, including posters and question and answer sessions at the end of the presentations, will check whether the students are able to present their results comprehensively and according to scientific standards. Students work on their work independently outside of the attendance phase. In addition, the students should show that they have understood basic and advanced programming concepts and are able to implement them.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

Recommended prerequisites for successful participation are basic engineering informatics, e.g. in the modules 'Bau- und Umweltinformatik I (BGU65004)' and 'Bau- und Umweltinformatik II (BGU44011)'. Students should be able to understand and use the basics of a programming language (data types, control structures, functions). In addition, an understanding of common software development methods, for teamwork in software, data security and time management is helpful (such as module BGU44013T2).

**Content:**

Coordination, development and testing of software for problems from engineering practice and/or problems of scientific relevance in teams (3 students). The assigned problems are either part of active research or originate from developments in industry. Team and project is supervised and supported by close cooperation with industry partners and/or research groups. Each project includes fundamental training, literature research, software development and frequent scientific reviews/presentations about the project's progress.

**Intended Learning Outcomes:**

Participants of this module have practical experience in the conception, implementation, and interpretation of computer-aided solutions for problems from engineering and science, including design and application of engineering software. They are familiar with interdisciplinary problems and the coordinated work in international project teams.

**Teaching and Learning Methods:**

The module consists of a practical training, consisting of group meetings with the project supervisors and three presentation dates including discussion. In the group meetings, the theoretical foundations of the project task are taught by the supervisors and references are given to appropriate literature sources. Furthermore, project progress will be checked regularly, new work packages will be set up and open questions answered. Implementation of the work packages is then performed independently by the students outside the attendance period. The students participate in the lectures both as presenters and as an audience. They are required to communicate their project status in a clear and understandable way and to lead constructive discussions about the presented contents.

**Media:**

Students present & discuss the progress of each project in three plenary sessions distributed over a two-semester working period.

**Reading List:**

Overall:

John Sonmez - Soft Skills: The software developer's life manual

Agile Software Development, Principles, Patterns, and Practices - Robert C. Martin

Further Literature is provided problem dependent by your supervisor

**Responsible for Module:**

Prof. André Borrmann; Modubeauftragter: Felix Eickeler (felix.eickeler@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Software Praktikum / Software Lab (Seminar, 2 SWS)

Clever J, Abualdenien J, Braun A, Ertl C, Esser S, Kopp P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### **BV250050: As-built Surveying and geodetical Monitoring | Baubestandsaufnahme und Bauwerksüberwachung**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The assessment method may vary between a 60-minute written exam or an oral test depending on the number of attendants. The used method will be announced in time.

It is examined, whether students are able to describe the basic geodetic instruments and methods in as-built surveys and geodetic monitoring tasks and to explain the characteristics of usage in own words.

No resources are allowed during the assessment.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

#### **Content:**

Reference systems and projections, as-built surveys and terrestrial Laserscanning, total stations and precise levelling, global satellite navigation systems, network adjustment, basics in geodetic monitoring, inclination measurements, deformation analysis, case studies, problem solving, recent research

**Intended Learning Outcomes:**

After applying the module courses students are able to understand the basic geodetic instruments und working principles used in as-built surveys and geodetic monitoring considering theory, usability and evaluation strategies. With that, they are able to ensure the mutual communication between different engineering experts working together on complex construction and environmental projects.

**Teaching and Learning Methods:**

Basic concepts are taught in a lecture, combined with case-study examples. Practical usage und explicit calculation and evaluation examples can be practiced in four half-day field exercises.

**Media:**

Power Point script

**Reading List:****Responsible for Module:**

Prof. Dr.-Ing. habil. Thomas Wunderlich, [th.wunderlich@tum.de](mailto:th.wunderlich@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

As-Built Surveys and Geodetic Monitoring (Vorlesung, 2 SWS)

Holst C, Wiedemann W

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV360009: Life-cycle Assessment | Ökobilanzierung

Version of module description: Gültig ab winterterm 2017/18

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The course's performance assessment will be one written exams. The written exam will test the students' ability to reproduce precisely the essential elements of life cycle assessment in general and in the context of building constructions as well as transfer this knowledge to different setting in a limited amount of time. The integration of case studies tests their knowledge, understanding and the ability of identification and adaptation of basic principles under time pressure. The exam consists of case studies, knowledge and comprehension questions and problems as well as of multiple-choice questions, calculations and open questions.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Grundlagen der Nachhaltigkeit

#### Content:

The module 'Lifecycle Assessment' takes place during winter semester. The essential content of the course is the Life Cycle Assessment Method and cross-linked thinking regarding environmental aspects, interdependencies and the interpretation of these.

The course 'Lifecycle Assessment' gives an overview over the context of Life Cycle Assessment and different, alternative assessment methods. Therefore, the course illustrates general aspects and processes of a LCA as well as specific characteristic of LCA in the building sector. This distinction enables the students to draw nuanced conclusions to decisions and approaches of action. The international and national regulation form the basis of this seminary. The elemental knowledge to compile a LCA consists of:

- Goal and scope definition
- Lifecycle inventory analysis (LCI) and product systems

- Lifecycle impact assessment (LCIA), indicators and endpoint categories
- Interpretation, iteration and analysis
- Environmental product declaration and databases
- Allocation
- Substitution and End-of-Life aspects
- Recycling, use phase and lifetime of building components

A workshop with focus on the application of this method, parallel to the lectures enables a deeper understanding and practical application of the theoretic elements of the lecture. The realistic context with a building as an example offers a direct approach to deal with datasets, databases and to gradually build implement and build up a lifecycle calculation within MS Excel. Lectures from partners with practical experience offer an outlook to the wide range of possibilities for application and integration of LCA.

### **Intended Learning Outcomes:**

After participating in the module 'Life-Cycle-Assessment', students will be able to understand and apply the method of lifecycle assessment as well as to make use of the principal of cross-linked thinking regarding environmental aspects, interdependencies and the interpretation of these. This includes the basics of an environmental assessment, as well as the understanding and application of the functional principles considering the content, processes and methods of LCA. The can describe and understand the regulation background of LCA on an international and national basis. The participants will be able to design a goal and scope definition for the LCA of products and buildings and to develop and perform the calculation. The students can master the application and interpretation of datasets and databases (like ökobau.dat, ecoinvent etc.) quantitatively and understand the principle of operation of different LCA-tools (like eLCA, LEGEP, GaBi etc.). The will also be able to interpret the results appropriately.

### **Teaching and Learning Methods:**

The module consists of lectures and practice sessions with blackboard and presentations. Additional practice sessions supplement the lectures by the application and calculation in MS Excel. The students can process case studies and systematic tasks for individual learning.

### **Media:**

Presentations, blackboard presentations, script (lecture-slides) transcript

### **Reading List:**

Script and literature from the mandatory pre-requisite modules, personal transcript will be necessary

- Informationsportal Nachhaltiges Bauen: [www.nachhaltigesbauen.de](http://www.nachhaltigesbauen.de)
- IPCC Reports
- Water Footprint Assessment Manual (2011)
- Ecological Footprint Atlas (2010)
- ILCD Handbook - General guide for LCA (2010)
- Humbert et al. (2012) - Impact 2002+ User Guide

- Rüter et al (2012) - Ökobilanz-Basisdaten für Bauprodukte aus Holz
- Klöpffer, W. (2014) - Ökobilanz (LCA)
- Kohler, König et al. (2010) - A life cycle approach to buildings
- Khouli, John et al (2015) - Sustainable Construction Techniques
- Guinée et al (2001), LCA - An operational guide to the ISO-standards
- Eyerer, P.: Ganzheitliche Bilanzierung, Werkzeug zum Planen und Wirtschaften in Kreisläufen; Springer Verlag; Heidelberg, Berlin, New York (1996).
- DIN EN ISO 14040:200911 Umweltmanagement Ökobilanz Grundsätze und Rahmenbedingungen
- DIN EN ISO 14044:200610 Umweltmanagement Ökobilanz Anforderungen und Anleitungen
- DIN EN 15804:2014-07: Nachhaltigkeit von Bauwerken - Umweltproduktdeklarationen - Grundregeln für die Produktkategorie Bauprodukte
- DIN EN 15978:2012-10: Nachhaltigkeit von Bauwerken - Bewertung der umweltbezogenen Qualität von Gebäuden - Berechnungsmethode

**Responsible for Module:**

Stefan Winter (bauko@bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Ökobilanzierung (Vorlesung mit integrierten Übungen, 2 SWS)

Winter S [L], Hartmann M, Ott S, Wagner A, Ebert S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV400016: Scientific Paper Writing | Selbständig wissenschaftlich Arbeiten

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Students have to submit a scientific paper which will be assessed based on a number of standard criteria for a scientific paper. The students demonstrate with their papers that they have gained deeper knowledge of the specific requirements of a scientific paper, including structure, appropriate presentation of information and discussion as well as the related formalities. The students are able to develop a topic for their papers and formulate the problem statement, objectives and research questions. Furthermore, the students are able to develop a conceptual frame and present as well as analyze information and formulate conclusions. Finally, the students are able to meet the formalities of a scientific paper including proper quotations, layout and language.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

#### (Recommended) Prerequisites:

none

#### Content:

1. Introduction into what constitutes a scientific paper and what not. How does a scientific paper differ from a technical or consultancy paper?
2. search ing and selecting literature.

3. Technical writing skills – structure and elements of an abstract, summary, position paper, essay
4. Formulating key problem statement and objectives for a research paper
5. Reading, understanding and reviewing research papers
6. Technical writing – macro-writing, outlining
7. Referencing and citing literature using referencing software
8. Technical writing – micro-writing and technical English
9. Technical writing - Use of frameworks in research papers
10. Executing Constructive peer reviews
11. Revising and improving papers

**Intended Learning Outcomes:**

At the end of the module the students understand the main steps to prepare, write, revise and review a scientific paper. More specifically, students are able to formulate a relevant problem statement, research objective and key method for a scientific paper and design an outline for such a paper. Furthermore, the students are able to write a scientific paper by presenting and following a clear line of argument, discussion and conclusions. The students are also able to identify scientifically valid sources of information and provide references in a given reference style using a reference software. Finally, the students are able to conduct collaborative work in an academic environment.

**Teaching and Learning Methods:**

The instruction is through participatory lectures, exercises and feedback to papers. Teaching method includes presentation and group discussion which help students to understand how to do a scientific research.

**Media:**

Presentations followed by discussion.

**Reading List:**

The module works with a background script in which different aspects of scientific paper writing are addressed.

**Responsible for Module:**

Walter T. de Vries wt.de-vries@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Scientific Paper Writing (Vorlesung, 1 SWS)

de Vries W [L], de Vries W ( Duran Diaz P )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV430002: Integral Transform Methods | Integraltransformationsmethoden

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>30   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcome of the Integral Transform Methods module is confirmed by passing a 60 minute written or a 20 minute oral examination. The examination modalities are published at the beginning of the lecture period and depend on the number of participants.

The aim of the examination for Integral Transform Methods is confirmation that the key concepts which relate to integral transformations have been understood and can be concisely recalled and implemented. Furthermore, problems must be analyzed and solution approaches found within a limited time using the learning outcomes achieved during the module.

The solutions sometimes require the student's own interpretation, in part selection of Single or Multiple Choice answers, whereby the emphasis is on short calculation exercises.

No auxillary means are allowed in the examination.

#### Repeat Examination:

#### (Recommended) Prerequisites:

- Basic knowledge in Differential- and Integral calculus
- Basic knowledge in statics
- Basic knowledge in dynamics

#### Content:

In this module Integral Transform Methods (ITM) are discussed focusing on the Laplace- the Fourier- and the Wavelet- Transformations. Mathematical relationships are derived and



applications for solutions of ordinary and partial differential equations and systems of differential equations are discussed.

Mechanical problems in the field of civil and mechanical engineering are assigned to the differential equations and solved using ITM. The analytical implementation in Computer Algebra Systems as well as numerical codes are discussed and practiced in computer seminars.

The effects attributed to discrete transforms are illustrated and different methods designed to cope with them are discussed.

The thematic outline is as follows:

- Continuous Laplace Transformation (transformation relationships and rules, differentiation in the transformed domain, shifting theorem, convolution theorem, inverse transformation with a partial fraction decomposition, complex inversion formula, Cauchy's principle value, residua theorem, systems of ODEs of the nth order and partial differential equations)
- Continuous Fourier Transformation (transformation relationships and rules, differentiation in the transformed domain, shifting theorem, convolution theorem, ODEs, transfer functions and partial differential equations)
- Continuous Wavelet Transformation (transformation relationships and rules, Wavelets, application examples)
- Discrete Fourier Transformation (windowing and filtering, algorithms and implementation)
- Fast Fourier Transformation (Algorithm and implementation)
- Short-term Fourier Transformation (Phenomena and connection to mechanical tasks)
- Discrete Wavelet Transformation (Phenomena and implementation)

### **Intended Learning Outcomes:**

After the successful participation in Integral Transform Methods, students are able to understand the fundamental mathematical contents of Integral Transform Methods as well as the differential equations describing mechanical systems. The students can apply the method of integral transformation to said differential equations, or systems of differential equations and analyze the results. The students are able to evaluate the applicability of the learned methods to the mechanical tasks and to use them specifically. These tasks are, e.g., the dynamic response of SDOF and MDOF systems under different types of loads whilst taking initial conditions into account as well as the time line analysis.

### **Teaching and Learning Methods:**

Instead of an ordinary lecture, teaching videos are provided via Moodle. Due to this new approach, students are able to study the complex contents of Integral Transform Methods with their individual speed. Exercises are offered to support the students in applying the basics and concepts taught in the videos to problem cases. Depending on the needs, students will be supplied with exercise sheets to help deepen their understanding and practical application.

**Media:**

Teaching videos are provided via Moodle. Tablet PC and digital projector, slides or the blackboard may be used during the sessions in the lecture hall. Exercise sheets and tasks may be published online as required.

**Reading List:**

- Bracewell, R., The Fourier Transform & Its Applications, McGraw-Hill, 1999
- LePage, W., Complex Variables and the Laplace Transform for Engineers , Dover Publications, 1980
- Debnath, L., Integral Transforms and Their Applications, Second Edition, Chapman & Hall/CRC, 2006

**Responsible for Module:**

Prof. Dr.-Ing. Gerhard Müller

**Courses (Type of course, Weekly hours per semester), Instructor:**

Integral Transform Methods - Theory and Application - Vorlesung (Vorlesung, 2 SWS)  
Müller G, Schneider F

Integral Transform Methods - Theory and Application - Übung (Übung, 2 SWS)  
Schneider F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV430008: Structural Dynamics | Baudynamik

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105  | <b>Contact Hours:</b><br>75          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcome will be confirmed by passing a 90-minute examination.

The aim of the written examination is the confirmation that the key models and methods of structural dynamics in civil engineering, including models for single and multiple degree of freedom systems, determination and solution of differential equations of motion for the key load situations of both discrete and continuous systems, as well as the fundamentals of stochastic, aero elastic and seismic oscillations, can be concisely reproduced, applied and evaluated. Furthermore, problems have to be analysed and solution approaches have to be found within limited time, based on the learning outcomes achieved during the module.

The solutions sometimes require the student's own interpretation or the selection of multiple choice answers. The emphasis of the examination is on short calculation exercises.

No auxiliary means are allowed in the examination with the exception of a provided formulary and a scientific calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The contents of the modules Technical Mechanics I (BV000001), Technical Mechanics II (BV000004) as well as Technical Mechanics - Supplementary Module (BV000038).

#### Content:

Thematic outline of the module Structural Dynamics in Civil Engineering:

- Overview over technical guidelines for structural dynamics in civil engineering
- Forecasting methods in dependence on the frequency and the boundary conditions/geometry of the system
- Classification of impacts

- Description of harmonic oscillations by complex numbers
- Description of oscillations in the frequency domain via Fourier Transformation
- Internal and external dynamic forces of harmonic oscillations, reaction forces
- Modelling by means of impedances
- Establishment of the differential equation of motion for Single-Degree-Of-Freedom-Systems (SDOF-Systems) and Multiple-Degree-Of-Freedom-Systems (MDOF-Systems) by means of the equilibrium relationships, the principle of virtual work and the principle of Hamilton
- Establishment and solution of the differential equation of motion of continuous systems
- Free oscillation of SDOF-Systems and MDOF-Systems
- Solution of the differential equation of motion for SDOF-Systems under harmonic, periodic or aperiodic loads in the frequency and time domain
- Solution of the differential equation of motion for MDOF-Systems under arbitrary loads in the frequency and time domain by means of the direct method and the modal analysis
- Fundamentals of stochastic oscillations
- Fundamentals of aero elastic oscillations (wind)
- Fundamentals of seismic oscillations
- Analytical solutions for selected systems like ropes, the Euler-Bernoulli-beam as well as bars with normal or torsional stress
- Numerical methods (time-step-methods)

#### **Intended Learning Outcomes:**

After the successful participation in the module Structural Dynamics in Civil Engineering, the students are able to evaluate different load characteristics. The students can choose and apply appropriate methods for the calculation of the system response of complex building structures. They can determine analytical solutions and classify numerical approximation methods. Additionally, the students can apply their basic knowledge about stochastic, aero elastic and seismic oscillations to simple problems.

#### **Teaching and Learning Methods:**

The module Structural Dynamics in Civil Engineering consists out of a lecture, exercises as well as a seminar. During the lectures, students were taught the theory of structural dynamic fundamentals for civil engineering by means of presentations, illustrative examples, real and abstract models as well as discussions. Furthermore, the lecture should motivate the students and encourage them to self-studies of additional literature. In the scope of the exercises, the main concepts of the lecture will be repeated and applied on selected examples. In addition to the lectures and exercises, voluntary exercise sheets are provided, with which the students have the opportunity to practice the taught methods. The students will work on the exercise sheets independently. To verify and discuss the solutions of the exercise sheets, a seminar is offered. Moreover, regular consultation hours are offered, where the students have the opportunity to clarify ambiguities with respect to the content of lectures, tutorials or exercise sheets in a personal discussion, and thus, to deepen their knowledge.

**Media:**

- Lecture notes and tutorial script (with gaps). Both with additions during the lectures (Tablet-PC with projector)
- Direct notes based on the writing on a Tablet-PC with projector during seminars
- Models/illustrative material for mechanical phenomena
- Animations
- Exercise sheets, the lecture notes and the tutorial script with gaps will be provided online

**Reading List:**

Bachmann: Vibration Problems in Structures. Birkhäuser, 1995  
Mehlhorn: Der Ingenieurbau, Band Baudynamik. Ernst & Sohn, 1995  
Ruscheweyh: Dynamische Windeinwirkung an Bauwerken. Bauwerkverlag, 1982  
Bracewell: The Fourier Transform & Its Applications. McGraw-Hill, 1999  
Petersen: Dynamik der Baukonstruktionen. Springer Vieweg, 2017  
Clough: Dynamics of Structures, McGraw Hill, 1975

**Responsible for Module:**

Prof. Dr.-Ing. Gerhard Müller

**Courses (Type of course, Weekly hours per semester), Instructor:**

Structural Dynamics - Tutorial (Übung, 2 SWS)

Kumawat A

Structural Dynamics - Seminar (Seminar, 1 SWS)

Kumawat A, Lainer M

Structural Dynamics - Lecture (Vorlesung, 2 SWS)

Müller G, Taddei F

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV470002: Geo Web Services | Geo Web Services

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>50   | <b>Contact Hours:</b><br>40          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The expected learning outcomes are verified in the form of a written examination (60 minutes). The written examination is to provide evidence that the students understand the technical foundations and the principle of Geo Web Services, are able to construct requests to Geo Web Services and to interpret responses correctly and are able to evaluate the usability of different types of Geo Web Services for selected use cases.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamentals of Geoinformatics, XML and XML Schema.

#### Content:

The module focuses on imparting knowledge about Geo Web Services. The content of the module is structured as follows:

- Principle of the Geo Web Service approach
- Fundamentals of the base technologies XML, XML Schema and HTTP
- International standards for Geo Web Service interfaces such as WMS, WFS, CSW, WPS, and SOS
- International standards for geospatial data formats such as GML and O&M

- Applications based on Geo Web Services in spatial data infrastructures and sensor networks

**Intended Learning Outcomes:**

After having successfully completed the module, the students are able

- to understand the technical foundations of Geo Web Services,
- to understand the principle of Geo Web Services in order to make geospatial data and functions available on the internet and to establish interoperability among geographic information systems and between geographic information systems and general IT systems,
- to construct requests to different types of Geo Web Services,
- to interpret responses from different types of Geo Web Services,
- to analyse international standards for Geo Web Service interfaces,
- to evaluate the usability of different types of Geo Web Services for selected use cases.

**Teaching and Learning Methods:**

Lectures for imparting the theoretical foundations.

Exercises on the computer for gaining practical skills in using selected Geo Web Services interfaces discussed in the lectures.

**Media:**

Presentations, XML editor software, Geo Web Service software

**Reading List:**

Standards of the Open Geospatial Consortium: <http://www.opengeospatial.org/standards>

**Responsible for Module:**

Thomas H. Kolbe ([thomas.kolbe@tum.de](mailto:thomas.kolbe@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geo Web Services (Vorlesung, 1 SWS)

Kutzner T

Übungen zu Geo Web Services (Übung, 1 SWS)

Kutzner T

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV470003: Harmonisation of Geospatial Data | Geodatenharmonisierung

Version of module description: Gültig ab summerterm 2020

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The expected learning outcomes are verified by an oral examination (30 minutes). The examination is to provide evidence that the students

- understand the methods for the harmonisation of geospatial data introduced in the module,
- are able to analyse use cases from the field of Geodesy and Geoinformation and
- are able to develop corresponding ETL processes.

The documentation of the ETL process the students develop within this module is an authorised learning aid during the examination.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamentals of Geoinformatics.

#### Content:

The module focuses on imparting knowledge about the harmonisation of geospatial data. The content of the module is structured as follows:

- Introduction to the technical terms related to geospatial data harmonisation
- Syntactic and semantic heterogeneity of geospatial data
- Geospatial data harmonisation in the context of spatial data infrastructures



- Selected methods of geospatial data harmonisation (selected semantic transformation methods, selected geometric transformation methods)
- Spatial ETL (Extract Transform Load) with the software FME

**Intended Learning Outcomes:**

After successful completion of the module students are able

- to understand the use of geodata harmonisation methods, e.g. spatial ETL (Extract, Transform, Load), for the combined usage of heterogeneous geospatial data from distributed systems, generally in the Geoinformatics domain and in the context of spatial data infrastructures (SDI),
- to apply a spatial ETL tool (software FME),
- to analyse use cases in the geodesy and geoinformation domain (e.g. semantic transformation in spatial data infrastructures, integration of measurement data or data from architecture and construction into GIS),
- to develop ETL processes for selected use cases.

**Teaching and Learning Methods:**

Lectures for imparting the theoretical foundations and the basic functions of a spatial ETL tool.

Exercises for gaining practical skills in applying the methods introduced in the lectures.

Development of an ETL process for solving a selected use case of geospatial data harmonisation as part of the self-study hours.

**Media:**

presentations,  
software FME.

**Reading List:**

provided by the lecturers/supervisors

**Responsible for Module:**

Thomas H. Kolbe (thomas.kolbe@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geodatenharmonisierung (Übung, 2 SWS)

Donaubauer A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV470015: Geodatabases | Geodatenbanken

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The learning outcome of this module is assessed with a written exam. The answers are partly own formulations and partly multiple-choice with an emphasis on short programming tasks. Goal of the written exam is to assess that the students understand the fundamentals of relational and object-relational database systems for storing and accessing geospatial data. Furthermore, it is assessed whether the language SQL can be applied by the students for querying geospatial data. Therefore problems have to be analyzed in limited time and, based upon the learning outcomes acquired in this module, solutions have to be found and implemented.

Participants are not allowed to use any technical aids and auxiliary material during the exam.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamentals of Geoinformatics.

#### Content:

Course "Introduction to Database Systems": data base modelling (conceptual and logical schema), transaction concepts, database indexing methods, SQL.

Course "Geodatabases": Introduction to spatial database systems, modelling spatial data (conceptual and logical schema), SQL and spatial SQL, concepts for storing spatial data in database systems, spatial data types and operators in database systems, spatial SQL exemplified by the spatial database system ORACLE spatial.

**Intended Learning Outcomes:**

At the end of the module students are able to understand the principles of a relational database system for storing spatial data; to understand the foundations of relational database systems; to apply methods for storing and retrieving spatial data in (object-) relational databases; to apply the language SQL.

**Teaching and Learning Methods:**

Lecture and exercises.

**Media:**

presentations, lecture notes, blackboard, PC exercises in individual work, supervised by tutors, Software ORACLE spatial.

**Reading List:**

Kemper, A. Eickler: Datenbanksysteme - Eine Einführung. Oldenbourg Verlag, 7. Auflage, 2009.

Kemper, M. Wimmer: Übungsbuch Datenbanksysteme. Oldenbourg Verlag, 2. Auflage, 2009.

Brinkhoff, Th.: Geodatenbanksysteme in Theorie und Praxis, Wichmann, Heidelberg, 2013.

**Responsible for Module:**

Thomas H. Kolbe (thomas.kolbe@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geodatenbanken (Vorlesung mit integrierten Übungen, 1 SWS)

Donaubauer A

Datenbanksysteme für Hörer anderer Fachrichtungen (IN4714) (Vorlesung, 2 SWS)

Kemper A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV470016: Advanced GIS for Environmental Engineering - Theory | Advanced GIS für Umweltingenieure - Theorie**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The expected learning outcomes are verified in the form of a scientific report (20-30 pages).

This report is to provide evidence that the students are able to apply the methods acquired in the module for coupling geographic information systems and simulation software. For this purpose, the students are provided with a task which they need to analyse and to break down into subproblems, which in turn need to be solved by means of the methods acquired in the module. The scientific report is prepared in the self-study hours.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Basic knowledge of GIS is required.

#### **Content:**

The module focuses on imparting knowledge about coupling geographic information systems with hydraulic simulation software. The content of the module is structured as follows:

- Fundamentals of object-oriented modelling with UML
- CityGML data model
- hydraulic simulation software OpenFoam

- OpenFoam data format
- object-relational database systems
- coupling concepts

This course provides a general introduction to the usage and possibilities of geographical information systems (GIS) for advanced applications in Environmental Engineering. The topics are in detail as follows: an overview of the possibilities of GIS, an introduction to GIS-based methods for hydrological and Environmental Engineering questions and guided tutorials for a specific GIS software.

**Intended Learning Outcomes:**

After having successfully completed the module, the students are able

- to understand the principle of coupling geographic information systems with hydraulic simulation software
- to understand the following data structures relevant for coupling: CityGML data model as example for a topographic information model, OpenFoam data format as example for a format of a hydraulic simulation software
- to apply an object-relational database system to be able to provide geospatial data for use in the hydraulic simulation software and to enrich the database by the simulation results

**Teaching and Learning Methods:**

Lectures for imparting the theoretical foundations.

Exercises on the computer for gaining practical skills in using selected components discussed in the lectures for coupling geographic information systems with hydraulic simulation software.

**Media:**

Presentations, Simulation, Database and GIS software

**Reading List:**

Literature is provided by the lecturer.

**Responsible for Module:**

Thomas H. Kolbe

**Courses (Type of course, Weekly hours per semester), Instructor:**

Advanced GIS for Environmental Engineering - Theory (Vorlesung, 2 SWS)

Nguyen H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV470018: Spatiotemporal Analyses in GIS | Raumzeitliche Analyse in GIS

Version of module description: Gültig ab summerterm 2020

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Goal of the written exam (duration: 60 Minutes) is to assess that the students understand methods to develop a spatio-temporal information system. Therefore problems have to be analyzed in limited time and, based upon the learning outcomes acquired in this module, solutions have to be found and implemented. The answers are partly own formulations and partly multiple-choice with an emphasis on short programming tasks.

Participants are not allowed to use any technical aids and auxiliary material during the exam.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamentals of geographic information systems as taught in the Bachelor courses GIS 1 and 2, or proof of equivalent knowledge.

#### Content:

- Data preparation (Java excel API)
- Data modeling (SQL)
- Data base: Oracle XE (data type: SDO)

- User interface(PHP, HTML)
- Apache web server
- Installation of GeoServer
- Configuration of a web map service
- Geostatistical methods (ESRI + own service)
- Spatiotemporal analysis

### **Intended Learning Outcomes:**

At the end of the module students are able to develop a geographic information system for spatio-temporal issues. They can develop a closed system for displaying location-based data and thus provide the technical basis for answering spatial research questions.

### **Teaching and Learning Methods:**

The module combines elements of a lecture with those of an exercise course. The fundamentals are taught teacher-centered by power point and back board work. In the exercise course this new skills are consolidated in team and individual work. Thereto guided assignments have to be solved. There are transfer task to ensure interdisciplinary skills and expertise. The exercise and lecture materials are provided in a comprehensive wiki.

### **Media:**

- PowerPoint
- Wiki
- Black board
- Blog
- Data base, GIS software

### **Reading List:**

- ULLENBOOM, Ch., 2006: Java ist auch eine Insel Das umfassende Handbuch Programmieren mit der Java Standard Edition Version 5.5., aktualisierte und erweiterte Auflage, 1. Nachdruck 2006, Bonn, 1456 S.
- Open Geospatial Consortium, 2004: OGC Web Map Service Interface Version 1.3.0
- GeoServer User Manual (online unter: [www.geoserver.org](http://www.geoserver.org))
- course wiki (access informatio is provided in the first lesson)

### **Responsible for Module:**

Thomas H. Kolbe ([thomas.kolbe@tum.de](mailto:thomas.kolbe@tum.de))

### **Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](#).

## Module Description

### BV480006: Digital Image Processing for Environmental Engineering | Digitale Bildverarbeitung für Umweltingenieure [IP]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Duration of examination (min.): 60 minutes.

The module examination is divided into two parts. The successful completion of the exercises including homework is considered as a "Studienleistung" (pass requirement). The results of the homework exercises are not included in the module grade. The module grade is determined by a written examination on the subject matter of the lecture and exercises.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

" MatLab basics

#### Content:

- " Introduction
- " Features of digital images
- " Image transformation
- " Segmentation
- " Binary image processing
- " Vectorization and geometric primitives



" Feature extraction

**Intended Learning Outcomes:**

At the end of the module students are able to

- " evaluate characteristic features of images,
- " create and to apply different image transformations,
- " analyze images by segmentation and feature extraction
- " analyse binary images and to assess results
- " compare image processing operations

**Teaching and Learning Methods:**

Lecture: Slides and lecture notes with small examples and discussion

Exercises: Small examples with programming in Matlab

**Media:**

Lecture: Slides, lecture notes, whiteboard

Exercises: Slides, exercise sheets, computer

**Reading List:**

Haralick, Shapiro (1992): Computer and Robot Vision (Vol. 1). Addison-Wesley, New York.

Castleman (1995): Digital Image Processing. Prentice Hall, Englewood Cliff, New Jersey.

**Responsible for Module:**

Uwe Stilla

**Courses (Type of course, Weekly hours per semester), Instructor:**

IPE - Image Processing (Vorlesung, 2 SWS)

Hoegner L [L], Xu Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV480007: Understanding Images - Basics | Bildverstehen - Grundlagen

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Examination is done in one written examination including the content of lectures and the exercises. No notes or other materials are allowed. The examination contains calculation questions as well as questions on methodical understanding and multiple-choice questions that do not cover more than 20% of the total points.

The questions on methodical understanding are used to prove that students understand the optical principles, image processing strategies, feature extraction methods and segmentation techniques. The calculation questions are used especially to prove that students are able to evaluate search strategies, semantics and grammars and production systems.

No aids are allowed.

The exercises contain calculation and programming parts that cannot be done in a written exam. Attendance and written documentations of the exercises is obligatory.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Introduction to Photogrammetry and Remote Sensing

Image Processing

**Content:**

- " Introduction
- " Image Processing in space and frequency domain
- " Feature extraction and segmentation
- " Image Processing in the visual system and Gestalt theory
- " Knowledge based image analysis
- " Production systems

**Intended Learning Outcomes:**

After the participation in the module students are capable of  
Analysing image processing strategies

- " Generate feature extraction methods and segmentation strategies
- " Understand the basic concepts in the visual system
- " Evaluate search strategies
- " Evaluate image analysis with production systems

**Teaching and Learning Methods:**

Lecture: Slides, lecture notes, small examples, guest lecturers

Exercises: seminary style, small examples with programming to be done as homework

**Media:**

Lecture: slides, lecture notes, whiteboard

Exercises: Slides, exercise sheets, programming

**Reading List:**

- Bunke H, Modellbasierte Bildanalyse, 1985
- Jähne B, Digitale Bildverarbeitung, Springer, 1993
- Bässmann H, Besslich PW, Konturorientierte Verfahren der digitalen Bildverarbeitung, Springer, 1989

**Responsible for Module:**

Uwe Stilla (stilla@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

IAB - Image Analysis Basics (Vorlesung, 2 SWS)

Hoegner L [L], Stilla U

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV480016: Introduction to Photogrammetry, Remote Sensing and Image Processing | Einführung in die Photogrammetrie, Fernerkundung und Bildverarbeitung [PRC+IPC]**

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>105  | <b>Contact Hours:</b><br>75          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The written exam takes 120 minutes with content of Photogrammetry and Remote Sensing on one hand and Image Processing on the other hand count both 50% of the achievable points. Questions contain drawing and explaining figures, answering questions on methods and solutions, calculations or comparisons of methods and their applicability. Additionally, multiple-choice-questions are including with statements that have to be evaluated as true or false. This part does not contain more than 20% of the total points. No aids or materials are allowed.

Additionally, 4 - 6 study projects are offered that can be used as a midterm exam and can be included in the module grade. They contain programming and documenting solutions for practical problems. As programming and documentation quality cannot be checked in an examination, this part is done as study work.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Linear algebra and MatLab basics for the exercises.

### **Content:**

During the lectures the following topics are covered:

- Definition Photogrammetry and Remote Sensing
- Characteristics of Photogrammetry and Remote Sensing, applications and development
- Stereoscopic vision and measurement, photogrammetric image analysis, digital stereo processing
- Radiometric basics, multispectral classification
- Optical basics: models and geometric quality of optical projections, description of image quality
- Introduction to Image Processing
- Features of digital images, image transformation, convolution, edge detection
- Segmentation
- Binary image processing
- Vectorization and geometric primitives
- Feature extraction

### **Intended Learning Outcomes:**

Upon completion of the module, students are able to...

- remember the physical basics of the electromagnetic spectrum and radiometric basics;
- understand concepts of photogrammetric image analysis;
- understand the principles of supervised and unsupervised classification;
- understand the principles of stereoscopic records;
- compare image processing operations.
- apply different classifiers and evaluate the classification results;
- apply different image transformations;
- analyse applications from different points of view;
- analyse images by segmentation and feature extraction;
- analyse binary images and to assess results;
- evaluate stereo records and produce anaglyph images;
- evaluate the influence of different factors on the image quality;
- evaluate characteristic features of images;
- plan aerial image campaigns;

### **Teaching and Learning Methods:**

The module consists of two lectures where the content is presented using slides, lecture notes, presentations and board. Applications and discussions activate the students to understand the contents. Important parts of the lectures are deepened in the exercise where students solve practical problems by mathematical calculations as well as small programming tasks.

### **Media:**

Presentations, hand-outs, exercise sheets, reading material

### **Reading List:**

Castleman, A. (1995): Digital Image Processing. Prentice Hall, New Jersey.

Haralick, S. (1992): Computer and Robot Vision (Vol. 1). Addison-Wesley, New York.

**Responsible for Module:**

Uwe Stilla (stilla@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

PRC-T - Übungen zur Photogrammetrie, Fernerkundung und Digitalen Bildverarbeitung (Übung, 1 SWS)

Hoegner L

PRC - Photogrammetry and Remote Sensing (Vorlesung, 2 SWS)

Hoegner L [L], Stilla U

IPC - Image Processing (Vorlesung, 2 SWS)

Hoegner L [L], Xu Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV480018: Applied Remote Sensing | Angewandte Fernerkundung [FEA]

Version of module description: Gültig ab summerterm 2020

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>45   | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The VO Applied Remote Sensing includes a written exam. The questions deal with the whole lecture's content. Aids are not allowed.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Photogrammetrie und Fernerkundung 1,2,3,4 of the Bachelor Geodäsie und Geoinformation

or

- Introduction to Photogrammetry and Remote Sensing

#### Content:

- Overview of recent remote sensing missions
- Detailed explanation of known missions with different sensors und different applications
- Organisation of remote sensing missions

#### Intended Learning Outcomes:

Know and evaluate remote sensing missions

**Teaching and Learning Methods:**

The VO Applied Remote Sensing transports its contents using oral presentations, slides and board, practical examples, and discussion.

**Media:**

- Lecture slides
- Lecture notes
- Exercise sheets
- Black / white board

**Reading List:**

**Responsible for Module:**

Uwe Stilla (stilla@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

FEA - Angewandte Fernerkundung (Vorlesung, 2 SWS)

Strunz G

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### **BV550025: System-Theoretical Principles of Risk Management for Business Processes and Real Estate Business Processes | Systemtheoretische Grundlagen des Risikomanagement in der Bau- und Immobilienwirtschaft [RM\_Baulmmo]**

Version of module description: Gültig ab summerterm 2012

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The elaboration of a respective project by a team of students proves not only their understanding of the learning content but also their ability to apply the methods, evaluate the results and consequences and moreover to develop the given approaches for further fields of utilization.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

none

#### **Content:**

Models and scenarios, definitions and statistics, activity based risk management, deficiencies of classical approaches, risk management in project business, transferring tasks and risks, development of knowledge, fault tree analysis (DIN 25424), state diagrams, theory of queues, equilibrium, theory of catastrophes, potentials, risk development in complex structures, parameters of structures, risk propagation, controlling risks in complex networks, theory of control, closely coupled control loops, modeling a project, criticality

#### **Intended Learning Outcomes:**

Having successfully completed the module the students will have understood the given learning content and will be able to apply and develop this further. Therewith, they know to analyze and evaluate applicable situations and solve respective problems when later professionally working.

**Teaching and Learning Methods:**

The learning content is taught via lectures and discussed in seminars. Supervised elaboration of specific subjects by teams of students (or as single persons) during the time of presence and beyond working on one's own are furthermore projected.

**Media:**

Lecture notes, power point-presentations, partially use of black/whiteboard, videoclips

**Reading List:**

Detailed lecture notes

**Responsible for Module:**

Dr. Wolfgang Eber (eb@bv.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Systemtheoretische Grundlagen des Risikomanagement in der Bau- und Immobilienwirtschaft / System-Theoretical Principles of Risk Management for Business Processes and Real Estate Business Processes (Vorlesung, 2 SWS)

Eber W [L], Eber W

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV600001: Risk Analysis | Risikoanalyse [RA1]

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a Klausur (duration 90 min).

With the exam the students prove that they are able to reflect and reproduce the contents of the modul. Also the Students demonstrate that they are able to describe and reflect important theories. Throughout the semester, students are given tasks based on the lectures, as well as homework and exercises to continuously check their level of knowledge.

All study materials, literature and simple scientific calculators are permitted as aids in the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The module will assume a basic knowledge of probability concepts such as random variables and their description (e.g., through completion of the BSc course "Zuverlässigkeit und Lastannahmen") [Modulnummer BV600003]. Basic Matlab knowledge is an advantage but not required (an introduction will be given).

#### Content:

1. Introduction, Data analysis using Matlab
2. Probability theory
3. Random variables
4. Parameter estimation
5. Probabilistic modeling of systems
6. Discrete probability models in engineering
7. Continuous probability models in engineering
8. Multivariate probability models

9. Functions of random variables
10. Monte Carlo simulation
11. Extreme value distributions
12. Random processes
13. Outlook

### **Intended Learning Outcomes:**

After participation in the module students are able to understand concepts of uncertainty and information. Students gain a profound toolbox for analyzing engineering problems subject to uncertainty and randomness. At the end of the module, students are able to:

- Know when to apply probabilistic methods and risk analysis
- Use the appropriate probabilistic model for individual and groups of variables
- interpret data analysis (statistics) using Matlab
- Apply Bayes rule for information updating
- Analyze the reliability of systems with statistically dependent elements
- use functions of random variables
- create stochastic process models
- Interpret the quality of a probabilistic analysis

### **Teaching and Learning Methods:**

The module consist of weekly lectures with integrated exercises from the fields of civil, environmental, structural, and mechanical and transportation engineering.

Lectures will be given on the blackboard, including selected illustrations. Case studies should help the understanding of the problems. The lecture notes in PDF form will be distributed at the beginning of the semester.

Simple examples for hand-calculation will be provided within the lectures and more realistic examples will be carried out using Matlab in the computer facilities of the department.

Short tests (15min) will be carried out during the semester, which serve to self-assess the learning success of students.

### **Media:**

- Lectures with blackboard supported by PowerPoint
- Exercises, partly using Matlab (which is available to all TUM students)
- Lecture notes including theory and examples
- Short tests
- 2 homework examples

### **Reading List:**

Lecture notes will be distributed. The following books provide useful supplemental material:

- Kottegod, N. T., and R. Rosso (2008), Applied statistics for civil and environmental engineers, Blackwell, Oxford.
- Ang, A. H.-S., and Tang, W. H. (2006). Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering, Wiley, New York.

- Benjamin, J. R., and C.A., C. (1970). Probability, Statistics and Decision for Civil Engineers, McGraw-Hill, New York.
- Bedford, T., and Cooke, R. (2001). Probabilistic risk analysis: foundations and methods, Cambridge University Press.

**Responsible for Module:**

Herr Prof. Dr. sc. Tech. Daniel Straub [straub@tum.de](mailto:straub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Risikoanalyse (Vorlesung mit integrierten Übungen, 4 SWS)

Straub D [L], Straub D, Bismut E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### ED110046: Internet of Things in the Built Environment | Internet der Dinge in der gebauten Umwelt

Version of module description: Gültig ab summerterm 2022

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The expected learning outcomes will be assessed in the form of a project work, which will be carried out in small groups. The assessment takes place in three oral presentations (a kick-off, an intermediate and a final presentation), a written discussion of original scientific literature (paper review), as well as a final written report on the project work. The presentations are suitable for reviewing the skills acquired during the project work. The presentations, followed by a discussion, are intended to test communicative competence in presenting one's own development results to an audience. The paper review aims at verifying that the students are able to critically deal with scientific publications in the field of Internet of Things (IoT).

The project report is intended to test the extent to which students are able to summarize results in writing or to document their own research and development results.

The project will be completed outside of in-class hours. Students must prove that they are able to independently develop a project from the topic area of the Internet of Things (IoT) and geosensor networks to a finished IoT application.

The weighting of the final grade is as follows: Presentations (kick-off, interim and final presentation) 30%, paper review 20%, written report on the project work (including assessment of the achievement of the project objectives) 50%.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic programming knowledge is expected, as taught in the first and second semester in the courses "Computer Science I" and "Computer Science II" of the bachelor degree program Geodesy and Geoinformation or Environmental Engineering. Knowledge in programming with C++, JavaScript, HTML, CSS, Python, SQL, etc., as well as the usage of web services are advantageous, but not mandatory.

**Content:**

The focus of the module is to provide skills for analysis, concept development and implementation of IoT projects where data is collected using sensors, transmitted to the Internet using various network technologies and managed, visualized and analyzed using open standards for geosensor networks.

The course includes an introduction to IoT hardware. Microcontrollers, a range of sensors, actuators and indicators, and the most common protocols for communication between controllers and peripherals will be introduced. Furthermore, communication hardware and protocols of microcontrollers are discussed. The focus here is on the low power wide area radio network technology LoRa and the LoRaWAN protocol. For sensor data management, the basics of interoperable open standards for geosensor networks (including OGC Sensor Web Enablement and SensorThings API) will be taught and standards-compliant services and protocols will be used. In addition, methods and tools for visualization and analysis of time series data will be presented and used during the course.

**Intended Learning Outcomes:**

After successful completion of the module, students are able to ...

- explain basic methods and technologies of the Internet of Things, geosensor networks and their applications,
- to evaluate scientific publications in the field of Internet of Things (IoT)
- develop, prototypically implement and document selected IoT projects and problems related to geosensor networks,
- to present the self-developed results in scientific form in front of an audience and to argue about them.

**Teaching and Learning Methods:**

In the first weeks of the course, lectures and scientific publications are used to teach the theoretical basics of the Internet of Things (hardware, protocols) and geosensor networks. In parallel, the students receive the project hardware and are introduced to the installation and programming of the components in the form of practical exercises with the supervisors.

Afterwards, the students independently develop a concept for the implementation of their own projects in small groups. The supervision of the project work takes place in weekly tutoring sessions with the tutors and lecturers.

**Media:**

Moodle e-learning, presentations, scripts, specific software

**Reading List:**

Will be announced at the beginning of the course

**Responsible for Module:**

Kolbe, Thomas; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geo Sensor Networks and the Internet of Things (Vorlesung mit integrierten Übungen, 4 SWS)

Kolbe T, Donaubauer A ( Willenborg B )

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### ED110059: Geokinematics | Geokinematik

*Reference systems, Earth system processes, geodynamics and climate change*

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Type of assessment: written exam

Duration of assessment: 60 minutes

The expected learning outcomes are verified by a written exam of 60 min duration. In the exam it is verified that the students understand the scientific challenges of space-based geodetic data sets and their potential for the determination of global and regional coordinate systems (reference systems) and geokinematic applications, that they are able to evaluate observation data with respect to its accuracy. With the discussion of typical examples and specific problem settings the theoretical understanding and the evaluation skills are examined. Through questions at different levels of difficulty, the written exam allows for an individual verification of the understanding and thus a realistic assessment of the acquired competencies.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Required: Knowledge in linear algebra, calculus, signal analysis, programming in Matlab.

**Content:**

1. Introduction: Earth System and its components. Concepts of geodetic reference systems and their fundamental role for the observation of Earth system processes, geodynamics and climate change.
2. The International Terrestrial Reference System (ITRS): General aspects, geodetic space observation techniques, realization of the ITRS and challenges.
3. Alternative reference systems (global vs. regional systems) and concepts for the treatment of temporal changes.
4. Current developments and most recent research topics: non-linear station motions, physical datum definition, the Global Geodetic Observing System (GGOS), inter-disciplinary scientific applications.
5. Signatures of Earth system processes, geodynamics and climate change in temporal changes of coordinates and their physical interpretation.

**Intended Learning Outcomes:**

After the successful conclusion of the module, the students are able

- to understand the fundamental role of highly precise geodetic coordinate systems as stable reference for the observation of Earth system processes, geodynamics and climate change.
- to understand the definition and realization of global highly-precise and long-term stable reference systems at mm-accuracy, in particular the fundamental "International Terrestrial Reference System" (ITRS),
- to classify different concepts for the realizations of geodetic reference systems (global, regional, epoch-wise, multi-year),
- to evaluate observations of space geodetic observation techniques regarding information content and accuracy,
- to describe the importance of accurate terrestrial reference frames for various inter-disciplinary applications,
- to understand geodynamic processes that are reflected by temporal changes of the positions of geodetic measurement stations (e.g. GPS stations),
- to discuss with experts from different geoscientific disciplines.

**Teaching and Learning Methods:**

The content of the course is taught in a lecture in interaction with the students. The learning success is continuously verified with questions. Mathematical derivations are shown at the black board. Selected literature is discussed with the students.

A guest lecture by an international expert is part of the module.

**Media:**

- Presentation slides
- Lecture notes/board content
- Selected scientific publications (made accessible for the participants)

**Reading List:**

- Lecture Notes

- Kovalevsky J., Mueller I., Kolaczek B. (1989): Reference Frames in Astronomy and Geophysics, Kluwer Academic Publishers, Dordrecht
- Seeber G. (2003): Satellite Geodesy, Walter de Gruyter, Berlin
- Xu G. (2010/2013): Sciences in Geodesy-I/II, Springer, Berlin
- Plag H.-P., Pearlman M. (2009): Global Geodetic Observing System, Springer, Berlin
- Selected scientific publications (made accessible for the participants)

**Responsible for Module:**

Seitz, Florian; Prof. Dr.-Ing. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geokinematics (Vorlesung, 2 SWS)

Seitz F [L], Bloßfeld M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **EI7467: Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country | Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country [ProRESDC]**

*Interdisciplinary Student Project Concept Development of a Renewable Energy System in a Developing Country*

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>135  | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The students' learning success will be determined by the following components of the project:

1. Input throughout the course of the milestone meetings (the supervisor of a team will rate each member of his team individually based on her or his input during the milestone meetings):
  - Integration of the extraneous inputs, which his team members from other fields of study give, in order to develop a holistic concept for a renewable energy system in a developing country
  - Analyzing the framework conditions, determining obstacles and deriving innovative solutions for renewable energy systems in developing countries before each milestone meeting
  - Communication with the team leader and the other team members
  - Meeting the timetable
2. Final presentation:

A jury will evaluate, how far the team manages to transfer their developed concept into an understandable context and to convince the audience of their choice of a certain concept. This includes the logic of the presentation, the focus on relevant points and appealing visualizations of their presentation slides.

In addition to this, each team member is individually evaluated for her or his presentation methods and expertise shown during the subsequent questions.
3. Project report (identical evaluation of all team members):

Here is rated how much convincing the decision was explained for the chosen energy concept and against other possible concepts due to the technological, financial and socio-cultural conditions and how comprehensible the implementation of the final concept was described.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

- Bachelor degree in a technical field of studies or in TUM-BWL
- Participation in "Series of lectures Renewable Energy Systems in Developing Countries"
- Interest in energy systems and their application / realization in developing countries
- Interest in the conversion of knowledge, which may differ from the field of her or his own studies on the one hand , but on the other hand is essential for the holistic understanding of their own study curriculum
- Interest in team-based project work and developing a realizeable concept
- Letter of motivation regarding study program, expertise, motivation and relevant experience (1.000 - 2.000 characters)

**Content:**

During the study project students develop a concept for the renewable energy system of a given location in a developing country.

During this concept development the variety of possible energy concepts will be reduced by general characteristics of stand-alone systems in the first step, followed by technological criteria in developing countries and socio-cultural impacts. Subsequently, the suitability of the various power production technologies, which are presented in the lectures, will be evaluated for the site in the developing country. Afterwards financing possibilities and framework conditions of regional market will be taken into account for the selection of the energy concept. In the end the final energy concept will be derived out of these sub steps.

Additionally the students derive options based on their developed energy concept, how to empower the population of the region economically by means of renewable energies.

**Intended Learning Outcomes:**

After participating in the project the students will be able to:

- understand extraneous knowledge concerning renewable energy systems in developing countries by the interdisciplinary collaboration with students from different study fields
- implement this interdisciplinary knowledge about energy systems in developing countries into action competences
- present the progress of a project target-oriented in meetings
- highlight the relevant technological, financial and sociocultural framework conditions of a planned energy system for a certain location in a developing country
- evaluate various options of energy supply concepts with based on their framework conditions
- manage the progress of a concept
- develop a suitable energy concept based on the requirements and possibilities of a defined location

- present convincingly their concept in a final presentation
- describe convincingly in a project report both the choice of their energy concept taking the involvement of all relevant aspects into account and the its realization

### **Teaching and Learning Methods:**

Students are expected to achieve the learning outcomes by means of a project internship. Interdisciplinary teams of students, consisting of students from various faculties, develop a concept for a renewable energy system for a particular location in a developing country in defined milestones. Each team is advised by a scientific assistant, who is their team leader. This advisor is managing the technical expertise of the team members with her or his project experience during the weekly milestone meetings.

Finally, each team presents its energy concept in a final presentation and in a project report. As a closing event there is offered a two-day excursion to an alpine mountain hut in Tyrol. Here both the the pros and cons of the concepts developed by the students are discussed to give the students the opportunity to reflect on their own work and that of their fellow students. Also the island energy system of the alpine hut, consisting of PV, biomass and battery storage, is shown in order to experience a realization of such a low-budget energy system.

### **Media:**

- Practical presentation of components using PowerPoint slides and scripts for the subsequent experiments (practical events)
- PowerPoint slides to define the milestones (milestone meetings)
- Final presentation using PowerPoint
- Project report using Word or Latex

### **Reading List:**

- Engineers without Borders UK in 2014 - Engineering in Development
- Scripts for each practical event
- Other thematic literature on the recommendation of the speakers of the lecture series

### **Responsible for Module:**

Hamacher, Thomas; Prof. Dr.

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Interdisziplinäres Projektpraktikum Konzeptentwicklung eines Erneuerbaren Energiesystems in einem Entwicklungsland (Forschungspraktikum, 4 SWS)

Hamacher T, Bazan S, Cadavid Isaza A, Pant P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### EI74831: Project Lab Renewable and Sustainable Energy Systems | Project Lab Renewable and Sustainable Energy Systems [PropENS]

Version of module description: Gültig ab winterterm 2018/19

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180         | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Participants of the Project Lab Renewable and Sustainable Energy Systems should carry out analyses, planning and applications about renewable energy systems and their modelling.

A team of 3-5 students should achieve a goal defined for the group over the duration of the lecture period of the semester within the framework of the project work. The problem definition, role distribution, idea development as well as the choice of suitable instruments, implementation and documentation are to be developed essentially independently by the group. The essential aspects of the work within the framework of the project internship (e.g. essential scientific contents, the treatment of a task as a completed project, division of the task among the group members) should be documented in a written report (volume: 15-20 pages).

In a supplementary presentation, the competence of the students to present their work in a structured way in a small seminar in front of an audience consisting of staff members of the chair and students will be examined. Overall, competencies in project work in the team as well as in documentation and presentation of the work should be demonstrated. The report is included in the grade with 40 %, the presentation and the cooperation in the team with 30%.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge about:

- Power systems
- Renewable energies (potentials, technologies)
- Matlab / Simulink

**Content:**

These are research-related and practice-oriented tasks whose topics are in line with the current research areas of the chair, such as:

- Modeling, simulation and / or regulation of energy systems
- Investigation of the potential of renewable energies
- Analysis and generation of data for energy systems
- Evaluation and interpretation of model results
- Planning and installation of plants for the use of renewable energies on the Campus Garching

**Intended Learning Outcomes:**

After successfully completing the module, the student is - depending on the topic - able to:

- recognize challenges of integrating renewable energies,
- apply and implement appropriate tools and methods to analyze, plan or regulate energy systems,
- interpret and evaluate results from applied models.

**Teaching and Learning Methods:**

Project tasks are carried out individually or preferably in groups of 2-4 students. In the process, self-dependence respectively teamwork is supported in the processing of a project task.

Depending on the topic, a literature research may be necessary. The main part of the project internship, however, is the computer-aided development of analysis and evaluation tools or the planning and execution of laboratory tests or installations.

The participants will finally have the opportunity to practice preparing and holding presentations.

**Media:**

- Application of various programs or programming languages (Matlab / Simulink, Python, etc.)
- Test benches (renewable energy conversion plants, real-time simulator, measuring instruments)
- Presentations

**Reading List:**

Konstantin, Panos: Praxisbuch Energiewirtschaft - Energieumwandlung, -transport und -beschaffung, Übertragungsnetzausbau und Kernenergieausstieg, Springer Vieweg, Springer-Verlag GmbH Deutschland, eBook ISBN 978-3-662-49823-1, DOI 10.1007/978-3-662-49823-1, Hardcover ISBN 978-3-662-49822-4

Wagner, Ulrich; Heilek, Christian (Bearb.): Nutzung regenerativer Energien (Vorlesungsskript), 10., vollständig überarbeitete Auflage, Herrsching, E & M, Energie-&-Management-Verl.-Ges., 2009, ISBN: 978-3-9805179-3-5

The Power of Transformation - Wind, Sun and the Economics of Flexible Power Systems, International Energy Agency, OECD/IEA, 2014, France, ISBN: 978 92 64 20803 2

Hillier, Frederick S., Lieberman, Gerald J.: Introduction to operations research, New York, McGraw-Hill Education, 2015, ISBN: 978-0-07-352345-3, 0-07-352345-3, 978-0-07-126767-0, 978-1-259-25318-8, 1-259-25318-X



**Responsible for Module:**

Hamacher, Thomas; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Projektpraktikum Erneuerbare und Nachhaltige Energiesysteme (Forschungspraktikum, 4 SWS)

Hamacher T, Kuhn P, Breuning L, Cadavid Isaza A, de la Rua Lope C, Halilovic S, Kerekes A, Kleeberger H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### MW1475: Renewable Energy Technology 1 | Regenerative Energiesysteme 1 [RET I]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam takes 60 minutes and consists of a number of short questions on certain aspects of the topics presented as well as some calculations. Allowed auxiliary are writing and drawing utensils and a non programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic thermodynamics and fluid dynamics

#### Content:

Content:

This course offers an insight into renewable energy sources, and the existing technologies to use them. It also looks to present the political framework of renewable energy technology, as well as societal and ecological aspects from a global point of view. The course is recommended for students not majoring in the field, who are interested in gaining an overview of renewable energy systems.

The course RENEWABLE ENERGY TECHNOLOGY (taught in English) is split into two modules 3 ECTS each (one per semester), beginning with "RET I" in the Winter Semester. The attached module "RET II" will be offered in the Summer Semester.

The course is supported by various institutions of the TUM: The Institute for Energy Systems, the Institute for Renewable and Sustainable Energies, The Institute for Wind Energy, The chair of Hydraulic and Water Resources Engineering as well as the "Laboratory of Steam Boilers and Thermal Plants" from the National Technical University of Athens.

The module "RET I" covers the following topics:

- Fundamentals
- Energy from Biomass
- Geothermal Energy
- Wind Energy

In the module "RET II" the following topics are covered:

- Hydropower
- Solar Thermal Energy
- Photovoltaics

From the winter semester 2017/2018 onwards  
the module "RET I" covers the following topics:

- Fundamentals
- Energy from Biomass
- Geothermal Energy
- Hydropower

whereas the module "RET II " is composed as follows:

- Wind Energy
- Solar Thermal Energy
- Photovoltaics

### **Intended Learning Outcomes:**

After the participation in the module the students are able to understand the basics of the most relevant renewable energy technologies.

The gained knowledge enables the students to describe the fields of application as well as the limits of the presented renewable forms of energy. Moreover, the students are able to explain the elementary aspects of renewable energies from a physical, technical, and economical point of view.

They are familiar with technological solutions of all the presented renewable forms of energy and are able to classify their fields of application.

In addition, the students are able to identify the most suitable technology for a given field of application with particular focus on key physical, technical, and economical issues. In this context, the students are able to list and explain the environmental, economic, and social impacts of the selected technology.

### **Teaching and Learning Methods:**

90 min lecture including discussion on the current topic per week. Students are encouraged to take part in the discussion and to question the arguments given by the lecturer. Autonomous preparing at home is needed to fully understand the learning matter.

### **Media:**

Powerpoint presentations

**Reading List:**

German Literature:

Kaltschmitt, Martin: Erneuerbare Energien. Springer Verlag, Berlin

Quaschnig, Volker: Regenerative Energiesysteme. Technologie - Berechnung - Simulation. Carl Hanser Verlag, München

Heliß, Michael: Regenerative Energiequellen. Praktikum. Springer Verlag, Berlin

Mohr, Markus: Chancen erneuerbarer Energiequellen. Springer Verlag, Berlin

English Literature:

Spliethoff, Hartmut: Power Generation from Solid Fuels. Springer Verlag, Berlin

Boyle: Renewable Energy. Oxford University Press

Kaltschmitt, Martin: Renewable Energy: Technological Foundations, Economical and Environmental Aspects. Springer Verlag, Berlin

Wengenmayr, Roland: Renewable Energy: Sustainable Energy Concepts for the Future. Wiley-VCH Verlag

International Energy Agency: Energy Technology Perspectives - Scenarios & Strategies to 2050

International Energy Agency: World Energy Outlook

**Responsible for Module:**

Spliethoff, Hartmut; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Regenerative Energiesysteme I (Vorlesung, 2 SWS)

Roeder G [L], Spliethoff H, Kunze C, Roeder G, Wieland C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### MW1476: Renewable Energy Technology 2 | Regenerative Energiesysteme 2 [RET II]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam takes 60 minutes and consists of a number of short questions on certain aspects of the topics presented as well as some calculations. Allowed auxiliary are writing and drawing utensils and a non programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic thermodynamics and fluid dynamics.

#### Content:

Content:

This course offers an insight into renewable energy sources, and the existing technologies to use them. It also looks to present the political framework of renewable energy technology, as well as societal and ecological aspects from a global point of view. The course is recommended for students not majoring in the field, who are interested in gaining an overview of renewable energy systems.

The course RENEWABLE ENERGY TECHNOLOGY (taught in English) is split into two modules 3 ECTS each (one per semester), beginning with "RET I" in the Winter Semester. The attached module "RET II" will be offered in the Summer Semester.

The course is supported by various institutions of the TUM: The Institute for Energy Systems, the Institute for Renewable and Sustainable Energies, The Institute for Wind Energy, The chair of Hydraulic and Water Resources Engineering as well as the "Laboratory of Steam Boilers and Thermal Plants" from the National Technical University of Athens.

The module "RET I" covers the following topics:

- Fundamentals
- Energy from Biomass
- Geothermal Energy
- Wind Energy

In the module "RET II" the following topics are covered:

- Hydropower
- Solar Thermal Energy
- Photovoltaics

From the winter semester 2017/2018 onwards  
the module "RET I" covers the following topics:

- Fundamentals
- Energy from Biomass
- Geothermal Energy
- Hydropower

whereas the module "RET II " is composed as follows:

- Wind Energy
- Solar Thermal Energy
- Photovoltaics

### **Intended Learning Outcomes:**

After the participation in the module the students are able to understand the basics of the most relevant renewable energy technologies.

The gained knowledge enables the students to describe the fields of application as well as the limits of the presented renewable forms of energy. Moreover, the students are able to explain the elementary aspects of renewable energies from a physical, technical, and economical point of view.

They are familiar with technological solutions of all the presented renewable forms of energy and are able to classify their fields of application.

In addition, the students are able to identify the most suitable technology for a given field of application with particular focus on key physical, technical, and economical issues. In this context, the students are able to list and explain the environmental, economic, and social impacts of the selected technology.

### **Teaching and Learning Methods:**

90 min lecture including discussion on the current topic per week. Students are encouraged to take part in the discussion and to question the arguments given by the lecturer. Autonomous preparing at home is needed to fully understand the learning matter.

**Media:**

Powerpoint presentations

**Reading List:**

German Literature:

Kaltschmitt, Martin: Erneuerbare Energien. Springer Verlag, Berlin

Quaschnig, Volker: Regenerative Energiesysteme. Technologie - Berechnung - Simulation. Carl Hanser Verlag, München

Heliß, Michael: Regenerative Energiequellen. Praktikum. Springer Verlag, Berlin

Mohr, Markus: Chancen erneuerbarer Energiequellen. Springer Verlag, Berlin

English Literature:

Spliethoff, Hartmut: Power Generation from Solid Fuels. Springer Verlag, Berlin

Boyle: Renewable Energy. Oxford University Press

Kaltschmitt, Martin: Renewable Energy: Technological Foundations, Economical and Environmental Aspects. Springer Verlag, Berlin

Wengenmayr, Roland: Renewable Energy: Sustainable Energy Concepts for the Future. Wiley-VCH Verlag

International Energy Agency: Energy Technology Perspectives - Scenarios & Strategies to 2050

International Energy Agency: World Energy Outlook

**Responsible for Module:**

Spliethoff, Hartmut; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Regenerative Energiesysteme II (Vorlesung, 2 SWS)

Roeder G [L], Hamacher T, Bottasso C, Breuning L, Roeder G, Sucameli C, Vannahme A, Wieland C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WI001255: Lecture Series Renewable Energy Systems in the Global South | Ringvorlesung Erneuerbare Energiesysteme im Globalen Süden

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>135  | <b>Contact Hours:</b><br>45          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Written exam of 60 minutes:

- In multiple-choice questions and short questions, it is examined if the students are able to name and explain facts regarding renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South correctly.
- In computational tasks, it is examined if the students are able to classify relevant location parameters correctly and perform calculations on renewable energy technologies correctly in order to design decentralized energy systems in the Global South according to the framework conditions of a certain location.
- In text tasks, it is examined if the students are able to classify and evaluate technological, economic and social factors influencing renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South correctly.
- The exam is graded.
- Up to 20% of the exam can be multiple-choice questions.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Bachelor degree in an engineering study program or a study program, which included technological/engineering aspects (such as B.Sc. Management & Technology)
- Interest in various renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South
- Interest in the socio-economic factors influencing the utilization of renewable energies in the Global South



### **Content:**

Overview of renewable energy technologies including their functionality, their technological and economical assessment, their integration in decentralized energy systems as well as business concepts for their utilization in the Global South:

- Renewable energy systems in the Global South - Why and how?
- Small-scale solar thermals and photovoltaics
- Small-scale hydro-power
- Small-scale wind-power
- Small-scale biogas systems
- Battery storages
- Electrical components of mini-grids
- Rural electrification planning through Geo Information Systems
- System sizing through least-cost modelling
- Sustainable energies and entrepreneurship in the Global South
- Sustainable enterprises for Renewable Energies in the Global South
- Rural electrification projects in the Global South

### **Intended Learning Outcomes:**

After successfully completing the module, students are able to

- Name and explain facts regarding renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South.
- Perform calculations regarding renewable energy technologies in order to be able to design decentralized energy systems in the Global South.
- Classify and evaluate technological, economic and social factors influencing renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South.
- Develop concepts for decentralized energy systems in the Global South based on the technological, economic and social framework conditions of a certain location.

### **Teaching and Learning Methods:**

Lectures and presentations by various researchers from TUM as well as entrepreneurs and other experts from the field of Renewable Energies in the Global South.

In exercise lessons, the taught knowledge of the lectures are applied to exemplary topics. After each lecture, the students conduct these exercises in homework and afterwards, these are discussed during the upcoming exercise lesson. Most of these exercises are calculating tasks about the technical components, but there are also some exercises regarding the financial assessment of renewable energy technologies. The exercises are not graded.

### **Media:**

The following media types are used:

- Computer-aided presentations for the lectures
- Exercises
- Discussion of provided literature

**Reading List:**

- Presentation slides of the speakers
- Solutions of exercise lessons
- Other literature recommended by the speakers

**Responsible for Module:**

Belz, Frank-Martin; Prof. Dr. oec.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ8088: Climate Change | Climate Change

Version of module description: Gültig ab winterterm 2012/13

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a 60-minute written test and a seminar work. In the written exam students answer theoretical questions and prove that they know the relevant theories and impacts of climate change. In the seminar work, (report and presentation) students prove that they understand detection methods for climate-related data and can analyse this data to present relevant conclusions.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in meteorology

#### Content:

This modul gives an overview on observed climate change, its impact on natural systems and the attribution of anthropogenic actions. In a lecture fundamentals of the physical basis, major impacts and attribution of climate change are explained and possible adaptation or mitigation actions are introduced. Additionally the students analyse and interpret climate/environmental data. Excursions on applied climate change demonstrate regional climate change on various topics.

#### Intended Learning Outcomes:

At the end of the module, students will know current theories concerning mechanism of climate change and understand climate change impacts on the environment. They are able to analyse climate-related data and interpret the results. They have the knowledge to detect impacts of climate change in various systems.

**Teaching and Learning Methods:**

The content of the course will be taught in lectures, presentations, seminars and excursions. Students should be encouraged to study literature and substantive discussion of the issues. Example tasks are provided and partially discussed.

**Media:**

**Reading List:**

IPCC (2013) Climate Change Fourth Assessment Report (AR5), additional literature is listed in the lecture.

**Responsible for Module:**

Nicole Estrella (estrella@wzw.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Fundamentals of Climate Change (Vorlesung, 2 SWS)

Estrella N

Climate change applied: from impact to mitigation (Seminar, 2 SWS)

Estrella N [L], Estrella N

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### WZ8100: Fundamentals of Climate Change | Fundamentals of Climate Change

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The written exam at the end of the term lasts 60 minutes. Here the students show without any additional help that their ability to answer questions concerning natural and anthropogenic causes and impacts of climate change on physical and biological systems on the basis of the topics of the lecture. The students shall prove that they are able to understand basic connections between causes and impacts of climate change

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge in meteorology, physics

#### Content:

This modul gives an overview on the theoretical background on the physical science basis of climate change, resulting observed changes in various physical biological and biogeochemical systems, and anthropogenic attribution, additionally actions for mitigation are introduced. This lecture is based on the newest IPCC report (AR 5).

#### Intended Learning Outcomes:

Students will become familiar with current knowledge concerning mechanism of climate change as well as climate change impacts on environment. They are able to analyse data and interpret the results. They have the knowledge to detect impacts of climate change in natural systems.

**Teaching and Learning Methods:**

Students will become familiar with current knowledge concerning mechanism of climate change as well as climate change impacts on environment. They are able to analyse data and interpret the results. They have the knowledge to detect impacts of climate change in natural systems.

**Media:**

IPCC (2013) Fifth Assessment Report of WGI, II, III. Houghton (2015) Global warming, the complete briefing. Most recent scientific literature

**Reading List:**

IPCC (2013) Fifth Assessment Report of WGI, II, III. Houghton (2015) Global warming, the complete briefing. Most recent scientific literature

**Responsible for Module:**

Estrella, Nicole; Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Fundamentals of Climate Change (Vorlesung, 2 SWS)

Estrella N

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## DTU Program - TUM Modules | DTU Programm - TUM Module

### Required Modules | Prüfungsmodule

#### Module Description

### BGU900011: Partner University - Elective Module | Partneruniversität - Wahlmodul

Version of module description: Gültig ab summerterm 2013

|                      |                     |                          |                       |
|----------------------|---------------------|--------------------------|-----------------------|
| <b>Module Level:</b> | <b>Language:</b>    | <b>Duration:</b>         | <b>Frequency:</b>     |
| <b>Credits:*</b>     | <b>Total Hours:</b> | <b>Self-study Hours:</b> | <b>Contact Hours:</b> |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

#### Intended Learning Outcomes:

#### Teaching and Learning Methods:

#### Media:

#### Reading List:

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU900011: Partner University - Elective Module | Partneruniversität - Wahlmodul

Version of module description: Gültig ab summerterm 2013

|                      |                     |                          |                       |
|----------------------|---------------------|--------------------------|-----------------------|
| <b>Module Level:</b> | <b>Language:</b>    | <b>Duration:</b>         | <b>Frequency:</b>     |
| <b>Credits:*</b>     | <b>Total Hours:</b> | <b>Self-study Hours:</b> | <b>Contact Hours:</b> |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

#### Intended Learning Outcomes:

#### Teaching and Learning Methods:

#### Media:

#### Reading List:

#### Responsible for Module:

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU900012: Partner University - Elective Module | Partneruniversität - Wahlmodul

Version of module description: Gültig ab summerterm 2002

|                      |                     |                          |                       |
|----------------------|---------------------|--------------------------|-----------------------|
| <b>Module Level:</b> | <b>Language:</b>    | <b>Duration:</b>         | <b>Frequency:</b>     |
| <b>Credits:*</b>     | <b>Total Hours:</b> | <b>Self-study Hours:</b> | <b>Contact Hours:</b> |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

#### Repeat Examination:

#### (Recommended) Prerequisites:

#### Content:

#### Intended Learning Outcomes:

#### Teaching and Learning Methods:

#### Media:

#### Reading List:

#### Responsible for Module:

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38014: Water and Wastewater Treatment Engineering | Wasserversorgung, Wasseraufbereitung und Abwasserbehandlung

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a written exam of 120 minutes duration.

Through theoretical questions students prove that they understand the individual stages for the elimination of wastewater constituents, the basics of water supply and wastewater management systems as well as necessity and feasibility of wastewater treatment methods, especially of municipal wastewater. Through application-oriented tasks, the students show that they can analyze resource management in the field of wastewater treatment, the performance of related systems, as well as location factors for water technology systems and can critically evaluate various conventional water and wastewater treatment techniques, taking into account urban and natural conditions. They also show that they are able to analyze water treatment problems in a limited time and apply the necessary procedures for the protection of public health, as well as to develop process optimization and solutions for municipal wastewater treatment considering technical and legal regulations.

The tasks often require own formulations, in some cases, multiple choice answers, the focus however being on short calculation tasks. In the exam, limited aids such as lecture handouts and personal notes are allowed. Not allowed are text books, internet and communication among themselves and with third parties.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Siedlungswasserwirtschaft Grundmodul (BGU38016)

Siedlungswasserwirtschaft Projektkurs (BGU38020)

#### Content:

1. Water supply resources and source protection; Character of raw water qualities

2. Regulatory and technical requirements
3. Processes to abstract, treat, store and distribute water for potable supply
4. Structure and organization of public water supply
5. Operation and maintenance of water treatment facilities
6. Character of wastewater, in particular municipal wastewater
7. Regulatory requirements and discharge standards
8. Approaches to treat municipal wastewater/resource recovery facilities
9. Fundamentals of biotechnology and microbial reactions/processes
10. Biological treatment processes
  - a. Activated sludge processes (aerobic, anaerobic)
  - b. Sequencing Batch Reactor (SBR) Technology
  - c. Biofilm reactors
11. Disinfection (chlorine-based; UV irradiation)
12. Biosolids stabilization and energy recovery from waste streams

### **Intended Learning Outcomes:**

After completion of this module course the students are able to:

- conceptually know and understand drinking water and wastewater treatment facilities and processes
- they will be able to apply the knowledge to select proper siting for drinking water facilities considering constraints within the urban and natural environment
- to analyze critical control points and evaluate the appropriate treatment unit processes to protect public health
- to create optimized treatment processes based on regulatory and technical requirements
- to know and understand the need and feasibility of wastewater treatment, with special emphasis on treatment of municipal wastewater
- to apply individual unit processes and operations to remove problematic constituents from wastewater using biological processes for organic and inorganic constituents as well as pathogens
- to analyze resource management related to wastewater treatment
- to conceptually create designs for conventional processes for wastewater treatment and evaluate their performance.

### **Teaching and Learning Methods:**

The module consists of a lecture with integrated exercises. In the lecture, the technical and legal requirements for water and wastewater treatment as well as the theoretical principles of mechanical and biological treatment methods are presented by means of presentations. Furthermore, holistic concepts for water and wastewater treatment are presented. On the basis of the lecture, the methods for water and wastewater treatment are worked into voluntary problem-solving exercises during class exercises and via the Moodle platform.

### **Media:**

Powerpoint presentations; Exercises in class and as voluntary homework via classworks during the lecture and via Moodle

**Reading List:**

Crittenden et al. (2012), Water Treatment Principles and Design , 3rd edition, John Wiley & Sons, New York, 2012

Edzwald, J. (2011), Water Quality & Treatment , 6th edition, McGraw Hill, New York, 2011

McGraw-Hill; 4th edition (2003). Wastewater Engineering Treatment and Reuse

Fourth Edition by Metcalf & Eddy, Inc.

Gujer, Willi (2007). Siedlungswasserwirtschaft. Springer, 3., bearb. Aufl.

**Responsible for Module:**

Prof. Dr.-Ing. Jörg Drewes (jdrewes@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Water and Wastewater Treatment Engineering (Vorlesung mit integrierten Übungen, 4 SWS)

Drewes J [L], Drewes J

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38021: Industrial Wastewater Treatment and Reuse | Industrieabwasserreinigung und Wiederverwendung

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The proof of performance is made in the form of a 60-minute written exam with questions on the fundamental understanding as well as small calculation tasks.

The aim of the written exam is the proof that the basic principles and approaches in the fields of industrial wastewater treatment, water reclamation and reuse, as well as integrated environmental protection measures are understood in industrial operation and different methods approaches can be applied comparatively. Problems need to be analyzed and based on learning outcomes acquired in the courses of the module students need to find and implement solutions in limited time.

The answers require partly own formulations, partly ticking given single or multiple answers and short calculation tasks. For the exam no aids are permitted except for a non-programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Participation in "Sanitary Engineering and Water Quality Basic Module" (BGU38016) and "Water and Wastewater Treatment Engineering" (BGU38014) is required. General requirement is basic knowledge of wastewater treatment is efficient.

#### Content:

Contents of the lecture are the definition of water flows and complexity of effluents of various industries with mostly organic or inorganic ingredients. Legal regulations, process and production integrated environmental protection, end-of-pipe technology also belong to the content of the lecture as well as mechanical, chemical and physical treatment methods, aerobic and anaerobic biological treatment (special procedures). Using examples from different industries both integrated



environmental protection measures, as well as wastewater treatment and wastewater reuse are described.

**Intended Learning Outcomes:**

Students are able to evaluate possibilities of integrated environmental protection measures and wastewater treatment processes and wastewater reuse in the industry. They know characteristics of industrial wastewaters compared to domestic wastewater. Students know which legal regulations for the treatment of industrial wastewater in Germany are necessary. Students are able to estimate combined methods (physical/ biological) for the elimination of toxic elements.

**Teaching and Learning Methods:**

The theoretical background and the current guidelines are presented in lectures. By means of example from industrial facilities and examples in the lecture, possible solutions are discussed and exemplified calculations are performed. On the basis of lecture notes in Moodle learned content can be repeated and internalized. The self-study is supported by the provision of further literature in Moodle.

**Media:**

Beamer, blackboard, power-point slides

**Reading List:**

Power-point slides as pdf in moodle

**Responsible for Module:**

Helmreich, Brigitte

**Courses (Type of course, Weekly hours per semester), Instructor:**

Industrieabwasserreinigung und Wiederverwendung (Vorlesung, 2 SWS)

Helmreich B [L], Helmreich B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38023: Engineered Natural Treatment Systems | Natürliche Aufbereitungsverfahren

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The proof of performance will be made in the form of a 60-minute written exam. The aim of the written exam is to prove understanding of basics and mechanisms of natural treatment systems and the ability to plan and design simple systems based on natural treatment processes by using existing guidelines. The answers mostly require partly own formulations, but also ticking given single or multiple answers and short calculations will be required. For the exam no aids are permitted except for a non-programmable calculator. The examiner will provide additional documents if needed for the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering

#### Content:

This module deals with processes and application of engineered natural treatment systems. Major abiotic and microbial transformation processes will be discussed in general and with respect to different applications including vertical flow and horizontal flow constructed wetlands, bank filtration and different applications of managed aquifer recharge technology. In addition, students will learn basics on enzymatic processes and reactions. The module also comprises engineering aspects for design and operation of engineered natural treatment systems as well as contents from ongoing research towards optimization of these systems and combinations with other treatment processes for water reuse.

#### Intended Learning Outcomes:

Upon successful completion of this module, students are able

- To describe major mechanisms and key parameters for contaminant removal in natural treatment systems
- To explain microbial and enzymatic processes and their dynamics in natural treatment systems
- To outline design of wastewater treatment with constructed wetlands for small communities based on local parameters
- To characterize methods and applications of bank filtration and groundwater recharge and discuss their potential for application in future water concepts

**Teaching and Learning Methods:**

Lehr- und Lernmethoden:

The module will be taught as a seminar by explaining major content in form of short lectures with integrated discussion. Furthermore, students will work in groups to develop solutions for selected case studies within the seminar. Additional field trips will help to further understand learned contents.

**Media:**

Presentation, group work

**Reading List:**

Will be announced at the beginning of the course.

**Responsible for Module:**

Hübner, Uwe (u.huebner@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Natürliche Aufbereitungsverfahren (Seminar, 2 SWS)

Hübner U [L], Hübner U

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38024: Advanced Water Treatment and Anaerobic Processes | Weitergehende Wasserbehandlung und Anaerobtechnik

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The examination of the module is a 120-minute written closed book test consisting of theoretical questions and calculation tasks.

The aim of the theoretical questions is to demonstrate that students understand approaches to typical tasks in fields such as water treatment and anaerobic technology, water reuse and energy recovery from urban residual streams. The students show that they are able to analyse and evaluate different treatment methods and select process approaches (including process concepts for anaerobic technology and energy recovery) for realistic problems. On the basis of practical tasks, they show that they are able to design sites for water reuse as well as estimate the related hazard potential and develop process optimisations using technical guidelines and legal requirements.

Students have to analyse water engineering tasks in a limited time, find and implement suitable solutions. The answers sometimes require own formulations, the focus being however on short calculation tasks.

Except for a non-programmable pocket calculator, no aids are allowed for the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Water and Wastewater Treatment Engineering (or equivalent courses on master's level)

#### Content:

- Introduction, regulatory and technical requirements of water reuse and seawater desalination

- Treatment trains to facilitate non-potable reuse
- Treatment trains leading to drinking water augmentation
- Advanced water treatment leading to water reuse: Ozone und Advanced Oxidation Processes (AOPs), Adsorption onto activated carbon (PAC, GAC), High-pressure membrane processes (Nanofiltration, reverse osmosis)
- Risk assessment and critical control points
- Process trains for seawater desalination; regulatory requirement
- Basics of anaerobic digestion
- Modeling of anaerobic digestion processes
- Treatment of sewage sludge (Introduction, agricultural use and incineration, recovery of phosphorous)
- Pre-treatment for enhanced digestibility
- Co-digestion
- Deammonification and CANDO
- Power to gas

### **Intended Learning Outcomes:**

After completing the module students are able to understand and remember the concepts and processes for advanced water treatment; analyse siting constraints within the urban and natural environment; they can evaluate process requirements and conceptually create design water reclamation and reuse facilities as well as seawater desalination plants. Based on the understanding of regulatory and technical requirements, students will be able to analyze critical control points to create schemes for treatment processes optimizations.

In addition, the students will be able to remember the basic process concepts of anaerobic processes and energy recovery, analyze and evaluate the advantages and disadvantages of the different methods for the specific application and develop simple approaches to calculate and dimension treatment schemes.

### **Teaching and Learning Methods:**

The module consists of two lectures. Theoretical basics as well as current guidelines are presented during the lectures. Approaches for the application of the different treatment methods are discussed in the lectures through practical examples. Exemplary calculations for the design of treatment methods and the assessment of risks are also carried out. In the subsequent exercise, the students apply the presented methods on further tasks. The self-study is supported by the provision of advanced technical literature in Moodle.

### **Media:**

Powerpoint presentations, black board, Exercises in class and as voluntary homework via Moodle

### **Reading List:**

Will be provided via Moodle

### **Responsible for Module:**

Jörg Drewes (j.drewes@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Advanced Water Treatment Engineering and Reuse (Vorlesung, 2 SWS)

Drewes J [L], Drewes J

Anaerobtechnik und Energierückgewinnung (Vorlesung, 2 SWS)

Koch K [L], Koch K

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU38028: Water Resource Recovery Process Simulation and Design | Prozesssimulation und Design von Kläranlagen

Version of module description: Gültig ab summerterm 2017

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>67   | <b>Contact Hours:</b><br>23          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Achievement of the course learning outcomes will be assessed through two voluntary mid-term assignments, and a graded final project.

For the final project, students will develop a model of a real-world wastewater treatment system using the dynamic wastewater treatment simulation software package BioWin, and evaluate various options for a major upgrade of the treatment system to meet new discharge regulations. The students' abilities to apply the wastewater treatment theory covered in lectures in the development of treatment system models, perform simulations, analyze and present simulation results in graphical and tabular form, and formulate engineering design recommendations will be evaluated. The final project will also be used to assess students' understanding of, and ability to explain, the role of key water resource recovery processes in achieving treatment goals and their ability to describe the design approaches and operational control parameters for these processes. The first voluntary mid-term assignment will also assess students' abilities to model wastewater treatment processes using BioWin; however, the modeling assignment will be more constrained than for the final project, and the emphasis will be on assessing students' progress in mastering the BioWin platform. Completion of the model development and simulations and preparation of the written report is designed to take 8 to 10 hours.

For the second voluntary assignment, students will work individually or in pairs to develop a modeling tutorial. The students will present background information on the model element being taught and the wastewater treatment process being modeled and will lead their fellow students through the completion of the tutorial. Successful completion of each voluntary course assignment will result in an improvement of 0.3 in the module grade.

#### Repeat Examination:

**(Recommended) Prerequisites:**

Water and Wastewater Treatment Engineering

**Content:**

The course will provide a critical link between the wastewater treatment theory covered in Water and Wastewater Treatment Engineering and the engineering practice of water resource recovery facility process design. Key concepts related to the design and operation of key treatment processes (including activated sludge, nitrification, biological nutrient removal, trickling filters, anaerobic digestion, and/or gravity and membrane solids separation) will be reviewed. The course will also introduce students to a dynamic modeling software package (BioWin). Students will learn how to apply engineering theory to build models of water resource recovery facilities and simulate their performance using BioWin.

**Intended Learning Outcomes:**

Upon successful completion of this module, students will be able to:

- Given the treatment and resource recovery goals for a wastewater flow, develop an appropriate treatment flow scheme and explain the role of each treatment process in achieving the treatment goals.
- Describe the key design approaches and operational control parameters for key water resource recovery processes.
- Use the dynamic simulation software package BioWin to construct models of water resource recovery facilities and perform steady-state and dynamic simulations of their performance for constant and dynamic, respectively, wastewater inputs.
- Generate data tables and graphs using BioWin and effectively describe model development and results in report form.
- Analyze simulation results and formulate engineering design recommendations based on these analyses.

**Teaching and Learning Methods:**

Lectures and active, in-class problem-solving exercises will be used to review key treatment design principles to ensure that all students have the necessary background needed to build meaningful models and perform useful simulations. Hands-on tutorials will be used to teach students how to build models of wastewater treatment systems and perform simulations using BioWin, a dynamic wastewater process simulator that is widely used by engineering consulting firms. Students will also work individually or in pairs to develop tutorials covering additional model functions to facilitate peer learning. Students will complete wastewater treatment and design assignments and a project to develop and facilitate assessment of their modeling abilities and creative problem-solving skills.

**Media:**

Modeling and tutorials using PC

**Reading List:**

Wastewater Engineering, Treatment and Reuse, Fifth Edition, Metcalf and Eddy, Inc. (M&E) by G. Tchobanoglous, F. L. Burton, and H. D. Stensel, ISBN-13: 978-0-07-340118-8



**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

Prof. Jennifer Becker

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46026: Alpine Hazards | Alpine Naturgefahren [Ri+Kr]

#### *Alpine Hazards*

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The module examination is a written, closed book test of 120 minutes duration. It consists of theoretical questions, practical tasks and calculations. Only a simple scientific calculator and a dictionary are allowed aids.

In the exam, the students demonstrate by answering theoretical questions that they can explain the main processes in alpine watersheds and analyse them concerning the flows of water, debris, the influence on land mass movements and the resulting hazard potential. Furthermore, they show that they understand the working mechanisms of measures for hazard mitigation in mountainous regions. On the basis of practical examples, they show that they can analyse realistic situations and apply mitigation measures in targeted strategies for alpine hazards. Through calculation tasks they prove that they can assess the quantitative aspects of the hazard side and the measure side.

#### **Repeat Examination:**

Next semester

#### **(Recommended) Prerequisites:**

Basic knowledge in Geology and Water Management.

#### **Content:**

Part 1: "Water Management in Mountain Regions"

The students get an introduction on the objectives and means of protective watershed management in alpine regions. The processes in natural landscapes, the relevant influencing factors on runoff and debris flow, the alpine water balance and relevant information sources for planning are outlined. On basis of this fundamental aspects the development of protection concepts, including strategies, requirements and boundary conditions are explained.

Finally the preventive measures with focus on constructional aspects like hydraulic and biological engineering, the management of alpine protective forest and measures for avalanches control as well as aspects of regional planning are presented and discussed.

## Part 2: "Process analysis, Modelling and Mitigation of Alpine Hazards"

The lecture will introduce process understanding of gravitational, nival, glacial and periglacial Alpine Hazards in dynamically changing mountain environments. This includes physical and mechanical aspects of process understanding and stochastic descriptions of magnitude and frequency patterns. On basis of this profound understanding, we will introduce benchmark approaches of how to model and anticipate selected gravitational, nival, glacial and periglacial Alpine Hazards.

These approaches will be evaluated with respect to the presently observed and anticipated Environmental Change in Alpine regions. This will be integrated into the development of sustainable adaptation and mitigation strategies in dynamic Alpine Environments. Best practice examples from different mountain environments will be assessed in a final step.

### **Intended Learning Outcomes:**

After a successful participation in the module the students are able to:

- understand the fundamental natural processes in alpine watersheds,
- understand the main issues in water and debris flow management
- understand the full range of gravitational, nival, glacial and periglacial Alpine Hazards in dynamically changing mountain environments
- analyse the relevant strategies and tools for protection works against alpine hazards
- apply scientific and practical strategies for process understanding, anticipation and mitigation of Alpine Hazards

### **Teaching and Learning Methods:**

The module consists of a lecture series. The theoretical framework of processes and dynamics of alpine hazards will be presented in the lecture. Practical Examples illustrate strategies and measures for the anticipation and mitigation of hazards. Furthermore, students are encouraged to study scientific literature in order to enrich the discussion of the issues. In class exercises, selected examples are calculated and distinct quantitative tasks are shown.

### **Media:**

Blackboard work and PowerPoint presentation.

### **Reading List:**

Script and PowerPoint slides provided from lecturers.

### **Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Prozessanalyse, Modellierung und Vorbeugung/Schutzmaßnahmen für Alpine Naturgefahren  
(Vorlesung, 2 SWS)

Krautblatter M, Rimböck A, Scandroglio R

Water Management in Mountain Regions (Vorlesung, 2 SWS)

Rimböck A ( Fuchs Y ), Fuchs Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46032: Hydraulics in Water Engineering Laboratory | Laborübung Wasserbauhydraulik [HWEL]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>50   | <b>Contact Hours:</b><br>40          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

- Moodle short-test (general questions): admission requirement, not graded
- Laboratory report: weighting 40%
- Presentation of results (with discussion for presence): weighting 60%

The short test ensures that the students have the necessary basic knowledge of the experimental topics.

In the laboratory report, the experimental results are documented.

In the presentation of the results for selected topics, it is to be demonstrated that the students have the required deeper understanding.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

- Hydraulic Engineering (recommended)
- Basic Module for hydraulic engineering and water management (recommended)
- Supplementary Module for hydraulic engineering and water management (recommended)

#### Content:

In the lecture "Hydraulics in Water Engineering" of the Master's degree programmes "Civil Engineering" and "Environmental Engineering", various complex flow conditions are dealt with, which hydraulic engineers are frequently confronted with in practice.

By illustrating these hydraulic processes in a physical model, students can gain a better understanding and at the same time be introduced to the practical use of measuring instruments and the evaluation of measurement data.

The following topics are covered:

- efficiency of weirs
- influence of weir pillars on the efficiency of weirs
- pressure profile on the weir shape
- characteristics of flap gates
- piano key weirs
- shaft spillway, side channel and chutes
- deep outlets
- bottom outlets
- stilling bassins
- surge chambers and water hammer
- cavitation

**Intended Learning Outcomes:**

After successful completion of this module, the students have a deep understanding of the complex hydraulic problems dealt with and can reliably work on them in their further professional life.

**Teaching and Learning Methods:**

- Introduction lecture (online via Zoom)
- one week of supervised exercises at the Hydro Lab in Obernach: measurements on the 8 subjects on physical models (each topic ½ day, in small groups), alternatively videos of the tests ! free accommodation in VAO's guest house for the duration of the course !
- evaluation and presentation of the results

**Media:**

Script, table work, exercise sheets, PowerPoint, movies

**Reading List:**

see lecture notes

**Responsible for Module:**

Dr.-Ing. Richard Huber (richard.huber@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Laborübung Wasserbauhydraulik (Übung, 3,5 SWS)

Huber R [L], Huber R, Scherbaum S, Schlagenhauer M

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46034: Hydraulic Machinery and Plants Laboratory | Laborübung Hydraulische Maschinen und Anlagen

*Laboratory Exercises HMA*

Version of module description: Gültig ab summerterm 2016

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>30   | <b>Contact Hours:</b><br>60                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Brief examination and written elaboration of test results.

The brief examination makes sure students have understood the fundamentals needed to conduct and understand the experiment. In the report, the students describe the experimental setup and the realisation of the experiment. They evaluate the measured data, represent them graphically and discuss their agreement with the theory. In doing so, they show that they are capable of conducting an experiment correctly as well as of representing and interpreting the experimental results.

#### Repeat Examination:

#### (Recommended) Prerequisites:

Basic knowledge of hydromechanics

#### Content:

Demonstration of hydraulic machinery and experimental techniques. Small groups of 5 participants perform measurements on pumps, water turbines and plant components and evaluate the results.

The following experiments are conducted:

- Measurement of pressure, pressure losses, flow velocity and discharge in pipes and in open flumes
- Determination of the operational characteristics (performance charts) of a centrifugal pump, a Pelton and a Francis turbine

**Intended Learning Outcomes:**

The students are able to understand the machinery and the flow phenomena connected with hydro power plants.

**Teaching and Learning Methods:**

lecture for imparting the theoretical background,  
discussion and deepening of the topics in the group sessions,  
demonstration and hands-on experiments on hydraulic machinery  
application of the knowledge in writing technical reports

The chosen course form makes sure that students understand the fundamentals required for the understanding of the experiment. While performing the experiments and writing up the reports the students learn to understand the flow phenomena by hands-on experience as well as to conduct an experiment correctly and to present and interpret the results obtained.

**Media:**

printed manuscript, power point presentations in the lectures

**Reading List:**

Reading list given in the manuscript

**Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Laborübung Hydraulische Maschinen und Anlagen (Übung, 2 SWS)

Alapfy B, Scherbaum S, Schlagenhauser M, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### BGU46035: Hydraulic Engineering and Hydromorphology | Wasserbauhydraulik und Hydromorphologie [HEHM]

Version of module description: Gültig ab winterterm 2022/23

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written exam (120 minutes, open book, allowed tools: notes, print medias (books, printed slides...), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

Concerning the practical tasks, the students show that they are able

- To precisely explain the design of hydraulic structures (e.g. weirs, dams) as well as the corresponding operating facilities and to design and assess hydraulic structures using calculations in a solution-oriented manner.
- To analyse sediment transport processes and to apply numerical modelling for estimating river morphological change and for designing technical measures in river engineering. A HEC-RAS project is included in the Hydromorphology part and will add additional points to the final exam when successfully completed.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Bachelor's level knowledge in hydraulic engineering, e.g.

- "Basic Module Hydraulic and Water Resources Engineering"
- "Supplementary Module Hydraulic and Water Resources Engineering"

#### Content:

The module provides in-depth knowledge of principles, methods and technologies for calculation and management of hydraulic engineering as well as hydromorphology.

- Fundamentals of hydraulics

- Normative regulations
- functionality, design and construction of hydraulic structures such as inlet structures, transport structures, outlet structures, energy dissipation structures, surge tanks
- danger to hydraulic structures e.g. cavitation, log jam, scour, vortex formations
- Discussion of dynamic loads, river diversions, construction process and safety concepts
- current examples will show actual facilities with their special problems and solution strategies
- typical design questions and calculations in hydraulic engineering
- one-day excursion to typical hydraulic structures in the pre-alpine/alpine area, on-going hydraulic engineering projects or constructions sites
- Introduction into Hydrodynamics
- Properties of sediment
- Sediment transport processes
- River morphology and the influence on sediment transport
- Stable channel design
- River response
- River stabilization
- numerical modelling of river morphology and sedimentation
- Computer Lab: HEC-RAS for Flow and sediment transport analysis

#### **Intended Learning Outcomes:**

After successful participation in the module, students will be able

- To design hydraulic structures such as weirs, dams and water supply structures in accordance with safety and normative regulations with regard to their hydraulic conditions
- To identify possible dangers to hydraulic structures and options how to avoid them
- To understand and apply modeling techniques and calculations in hydraulic engineering
- To understand and quantify the mechanisms of erosion, transportation and deposition of sediment by flow in the river
- To assess the effects of natural and human interference on river morphodynamics
- To apply hydromorphological numerical modeling and its applications in river work development

#### **Teaching and Learning Methods:**

- lecture style
- practical examples
- coordinated moodle tests (voluntary)
- small project work using HEC-RAS in groups of two-three students

#### **Media:**

- PowerPoint presentations with film sequences and computer animations
- blackboard exercises
- moodle tests (voluntary)
- lecture notes in moodle

**Reading List:**

see lecture notes

**Responsible for Module:**

PD Dr.-Ing. habil. Minh Duc Bui (bui@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

River Engineering and Hydromorphology (Vorlesung, 2 SWS)

Bui M

Wasserbauhydraulik (Vorlesung, 2 SWS)

Reisenbüchler M, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46036: Water Resources and Hydropower | Wasserwirtschaft und Wasserkraft [WRHP]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a written exam (120 minutes, open book, allowed tools: notes, print medias (books, printed slides...), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

The students will prove that they are able to apply modelling techniques in water management and to design the volumes and water levels of a reservoir.

Furthermore, they prove that they can design a water power station in concept and dimensioning as well as the state-of-the-art technologies for energy storage.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Bachelor's level knowledge in hydraulic engineering, e.g.

- "Basic Module Hydraulic and Water Resources Engineering"
- "Supplementary Module Hydraulic and Water Resources Engineering"

#### Content:

The module provides in-depth knowledge of principles, methods and technologies for calculation and management of water resources, as well as the sustainable generation of energy from hydropower.

- precipitation, runoff and runoff coefficient
- rainfall-runoff modelling

- flood routing
  - flood statistics
  - reservoir capacity
  - storage plans and operation schemes
  - flood retention
- 
- types of hydro power stations, specific requirements of large and small hydro power
  - elements of hydro power installations
  - hydro turbines: turbine types, application ranges
  - stream turbines: fundamentals, turbine types, application range
  - energy conversion in hydro turbines - physical fundamentals
  - planning of hydro power stations: hydrological surveys, layout, power plan
  - needs and requirements for energy storage
  - fundamental options for power storage
  - properties of storage technologies, pros and cons, application ranges, potential, development state, project examples
  - pumped storage plants: fundamentals, electromechanical equipment, new approaches

### **Intended Learning Outcomes:**

After successful participation in the module, students will be able

- to apply important and mainly used modelling techniques and calculation methods of water management
- to assess their application areas and limitations
- to design a reservoir under the aspects of hydrology and water resources management
- to describe, identify and assess established and newly proposed technologies of hydropower and energy storage
- to explain and assess the physical foundations of the energy conversion as well as the fundamental approach in planning hydropower projects
- to evaluate hydropower project plans and to perform planning themselves.

### **Teaching and Learning Methods:**

- lecture style
- practical examples
- coordinated moodle tests (voluntary)

### **Media:**

- PowerPoint presentations with film sequences and computer animations
- blackboard exercises
- moodle tests (voluntary)
- lecture notes in moodle

### **Reading List:**

see lecture notes

**Responsible for Module:**

Dr.-Ing. Richard Huber (richard.huber@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Sustainable Water Resources Management (Vorlesung, 2 SWS)

Huber R, Scherbaum S

Hydro Power and Energy Storage (Vorlesung, 2 SWS)

Reisenbüchler M [L], Reisenbüchler M, De Vos L, Schwedhelm H

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46038: Principles and Applications of Land Management | Prinzipien und Anwendung von Landschaftsmanagement

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment is based on a written exam of 90 minutes with open questions. Such open question test to which extent students can individually formulate feasible and plausible answers in their own words in relation to descriptions, explanations and analysis of basic conceptualisations of land management and landscape management. In addition, the open question should test to which extent students are able to formulate judgements and appropriate solutions for land management challenges and formulate appropriate research questions in relation to land management themes. During the exam only a hardcopy dictionary and a calculator are allowed.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic understanding of of law and environmental systems.

#### Content:

This module will provide foundational knowledge for sustainable land management in both rural and urban areas by a combination of two complementary approaches: land administration and landscape planning.

Land administration comprises of 4 fundamental components: cadastral land surveying, land registration, land valuation and land development. These components together rely on a land information infrastructure and provide the basis for systematic and comprehensive land interventions.

The module will address the guiding principles, formal instruments and procedural elements of Landscape Planning; present methodological approaches for the assessment of natural assets and landscape functions including methods and tools for data collection, analysis and evaluation; illustrate target formulation and implementation strategies with examples from the planning practice.

### **Intended Learning Outcomes:**

On successful completion of the module, participants should:

1. recognize, describe and explain core concepts and principles of responsible and smart land management, land administration and landscape management.
2. explain and apply basic tools, instruments and procedural elements of land administration (including cadastral mapping and land registration) and landscape management.
3. select appropriate methods and tools to design assess natural assets and landscape functions.
4. judge and assess the role and application of land management tools and instruments in the context of sustainable development challenges and requirements.
5. be able to transfer principles and apply tools of land management to secure land tenure, develop and plan urban and rural regions in a responsible and sustainable manner.

### **Teaching and Learning Methods:**

This module relies on active learning methods. The required background knowledge on each of the topics is introduced via both verbal/frontal lectures and via open access background papers and articles (which students have to read and comprehend during and via self study hours). Students are required to apply this knowledge either individually and/or in groups in exercises. The exercises are structured such that students have to combine different sources in order to derive and formulate feasible answers and/or solutions. The exercises are based on actual cases in both Germany and abroad. These seminar type exercises aim to transfer this knowledge for developing a tenure responsive and/or ecologically sustainable strategy at the neighbourhood and/or a national scale. Through these exercises the application of knowledge is practiced. For the exam these knowledge application experiences are required.

### **Media:**

Lectures provide subject specific knowledge; class discussions of selected readings engage students in critical thinking.

### **Reading List:**

Haaren, Chr. v., Galler, C. & S. Ott (2008): Landscape planning. The basis of sustainable landscape development. Ed. by Federal Agency for Nature Conservation; Further thematic reading will be made available in connection with the lectures and the seminar



**Responsible for Module:**

Prof. Walter Timo de Vries wt.de-vries@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Integrated Land and Water Management (Vorlesung, 4 SWS)

de Vries W, Disse M, Pauleit S

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46039: Ethics in Science and Technology | Ethik in Wissenschaft und Technologie

Version of module description: Gültig ab winterterm 2016/17

|                                |                             |                                   |                                             |
|--------------------------------|-----------------------------|-----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>two semesters | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>90    | <b>Contact Hours:</b><br>90                 |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment is done on the basis of a scientific report.(max. 5 pages)

The students take part actively in the seminar and take part in the discussions. The discussions allow a continuous improvement of the argumentation competence of the students. Through the study of special texts and project examples the knowledge of social challenges of the complex "Nexus - Water-Food-Energy" is improved. Through a presentation (approx. 20 minutes) of a related topic and a written summary with individual argumentation schemes the seminar is completed.

#### Repeat Examination:

End of Semester

#### (Recommended) Prerequisites:

Students must visit first the basic seminar to deepen their knowledge for the advanced seminar.

#### Content:

Scientists and engineers in science and economy at the beginning of their professional career partly face moral challenges which they are hardly prepared for in the traditional study plans. These problems can appear in public discussion or within the realisation of scientific innovations in research and industry. In a basic seminar the models of ethical argumentations are thought. Afterwards the students work on ethical challenges with realistic project examples from the Nexus complex "water-food and energy".

#### Intended Learning Outcomes:

The students develop a better understanding for the nature of the scientific work within the scope of interdisciplinary Nexus - Water, Food and Energy. They get to know the most important ethical

theories and can apply them. The students are enabled to separate technical and normative dimensions of a problem professionally and can develop criteria for a decision. The competence of problem differentiation, reflection, broad argumentation and critical power of judgement is explicitly promoted. The students can judge interdisciplinary projects.

**Teaching and Learning Methods:**

Text reading, talks preparation, problem differentiation, individual and group work, discussion, presentation and written elaboration.

**Media:**

Reader, Powerpoint, Film, Webplattform

**Reading List:**

**Responsible for Module:**

Dr. rer. nat. Eva Sandmann sandmann@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

Ethik in Wissenschaft und Technologie - Teil 2 (Vorlesung, 2 SWS)

Sandmann E

Ethik in Wissenschaft und Technologie - Teil 1 (Vorlesung, 2 SWS)

Sandmann E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46040: Ocean and Wind Energy | Meeres- und Windenergie [OWE]

*Potentials, fundamentals and technical possibilities of utilising ocean and wind energy*

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment consists of a written, closed books exam of 90 minutes duration.

The written exam is composed of comprehension and theory questions and comprises all subjects covered in the lecture. It assesses through questions and short tasks if the students are able to rate the potential of the different sources of renewable energy, describe technologies and applications of ocean and wind power plants and understand their economic and ecological implications. Questions targeted at understanding allow students to prove that they understand the link between technologies and the planning and dimensioning of ocean and wind power plants and show they are able to give comprehensive answers to such tasks within a limited time.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge of Fluid Mechanics, e.g. lectures

Fluid Mechanics, Module ID BV410008

Hydromechanics, Module ID BV410013

Fluid and Structural Mechanics, Module ID BV410014

#### Content:

The module consists of a lecture. It is giving an overview on the renewable energy sources wind and ocean energy and the technologies for their utilization in theoretical fundamentals and examples.

For each of the renewable energy carriers wind energy and ocean energy (tidal, ocean current, thermal, osmotic and wave energy) the following aspects are dealt with:

- \* overview over the fundamental utilization possibilities
- \* creation, magnitude and distribution of the potentials
- \* historical development of the technologies for the energetic utilisation
- \* fundamentals of the energy conversion
- \* functional principle, construction and properties of the established as well as suggested technologies and technologies being currently developed
- \* overview over former, recent and suggested projects
- \* construction/deployment and operation
- \* environmental considerations
- \* fundamentals of design and planning

### **Intended Learning Outcomes:**

After a successful participation in the module students are able to:

- know and judge the potentials of the renewable energy sources wind and ocean energy
- understand the processes which create these form of renewable energy
- understand, analyse and evaluate the established and newly suggested technologies for their utilisation
- understand and apply the physical and technical fundamentals applied in the energy transformation
- understand and perform layout and planning of plants for the utilisation of the above mentioned renewable energy sources
- evaluate the ecological impact of the technologies
- estimate potential risks and uncertainties of the technologies
- understand the economic chances and risks of the technologies

### **Teaching and Learning Methods:**

The module consists of a lecture. The theoretical content of the lectures is presented by the lecturer supported by PowerPoint slides and the traditional black board method. Accompanying exercise examples and discussions allow students to participate and to strengthen the interdependencies.

### **Media:**

Power Point presentations with video sequences and animations

### **Reading List:**

Hau, Erich; Wind Turbines: Fundamentals, Technologies, Application, Economics, Springer, Berlin; 2nd rev. ed. (15. November 2005) ISBN-10: 9783540242406, ISBN-13: 978-3540242406

Hau, Erich; Windkraftanlagen: Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Springer, Berlin; Auflage: 4., vollst. neu bearb. Aufl. (Januar 2008) ISBN-10: 3540721509, ISBN-13: 978-3540721505

Kaltschmitt, Martin; Renewable Energy: Technology, Economics and Environment Springer Berlin Heidelberg (9. Dezember 2009), ISBN-10: 3642089941, ISBN-13: 978-3642089947

Kaltschmitt, Martin; Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, Springer, Berlin; Auflage: 4., aktualis., korrig. u. erg. A. (25. August 2009), ISBN-10: 9783540282044, ISBN-13: 978-3540282044

Gasch, Robert: Windkraftanlagen, Teubner B.G. GmbH; 4. Auflage, Dezember 2005, ISBN-10: 3519363348, ISBN-13: 978-3519363347

Gasch, Robert, Jochen Twele: Wind Power Plants, Fundamentals, Design, Construction and Operation. ISBN: 978-3-642-22937-4 (Print) 978-3-642-22938-1

Charlier, R.H. and Finkl, C.W.: Ocean Energy – Tide and Tidal Power; Springer Verlag Berlin / Heidelberg 2009, ISBN 978-3-540-77932-2

Ross, David: Power from the Waves; Oxford University Press, 1995, ISBN 0-19-856511-9

McCormick, Michael E.: Ocean Wave Energy Conversion, Dover Publications Inc., Mineola, New York 2007; ISBN 978-0-486-46245-5

Arthur Pecher, Jens Peter Kofoed, Editors: Handbook of Ocean Wave Energy, Springer Open, Ocean Engineering & Oceanography ISBN 978-3-319-39888-4 ISBN 978-3-319-39889-1 (eBook)

**Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU46040: Ocean and Wind Energy | Meeres- und Windenergie [OWE]

*Potentials, fundamentals and technical possibilities of utilising ocean and wind energy*

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The assessment consists of a written, closed books exam of 90 minutes duration.

The written exam is composed of comprehension and theory questions and comprises all subjects covered in the lecture. It assesses through questions and short tasks if the students are able to rate the potential of the different sources of renewable energy, describe technologies and applications of ocean and wind power plants and understand their economic and ecological implications. Questions targeted at understanding allow students to prove that they understand the link between technologies and the planning and dimensioning of ocean and wind power plants and show they are able to give comprehensive answers to such tasks within a limited time.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge of Fluid Mechanics, e.g. lectures

Fluid Mechanics, Module ID BV410008

Hydromechanics, Module ID BV410013

Fluid and Structural Mechanics, Module ID BV410014

#### Content:

The module consists of a lecture. It is giving an overview on the renewable energy sources wind and ocean energy and the technologies for their utilization in theoretical fundamentals and examples.

For each of the renewable energy carriers wind energy and ocean energy (tidal, ocean current, thermal, osmotic and wave energy) the following aspects are dealt with:

- \* overview over the fundamental utilization possibilities
- \* creation, magnitude and distribution of the potentials
- \* historical development of the technologies for the energetic utilisation
- \* fundamentals of the energy conversion
- \* functional principle, construction and properties of the established as well as suggested technologies and technologies being currently developed
- \* overview over former, recent and suggested projects
- \* construction/deployment and operation
- \* environmental considerations
- \* fundamentals of design and planning

### **Intended Learning Outcomes:**

After a successful participation in the module students are able to:

- know and judge the potentials of the renewable energy sources wind and ocean energy
- understand the processes which create these form of renewable energy
- understand, analyse and evaluate the established and newly suggested technologies for their utilisation
- understand and apply the physical and technical fundamentals applied in the energy transformation
- understand and perform layout and planning of plants for the utilisation of the above mentioned renewable energy sources
- evaluate the ecological impact of the technologies
- estimate potential risks and uncertainties of the technologies
- understand the economic chances and risks of the technologies

### **Teaching and Learning Methods:**

The module consists of a lecture. The theoretical content of the lectures is presented by the lecturer supported by PowerPoint slides and the traditional black board method. Accompanying exercise examples and discussions allow students to participate and to strengthen the interdependencies.

### **Media:**

Power Point presentations with video sequences and animations

### **Reading List:**

Hau, Erich; Wind Turbines: Fundamentals, Technologies, Application, Economics, Springer, Berlin; 2nd rev. ed. (15. November 2005) ISBN-10: 9783540242406, ISBN-13: 978-3540242406

Hau, Erich; Windkraftanlagen: Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Springer, Berlin; Auflage: 4., vollst. neu bearb. Aufl. (Januar 2008) ISBN-10: 3540721509, ISBN-13: 978-3540721505



Kaltschmitt, Martin; Renewable Energy: Technology, Economics and Environment Springer Berlin Heidelberg (9. Dezember 2009), ISBN-10: 3642089941, ISBN-13: 978-3642089947

Kaltschmitt, Martin; Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, Springer, Berlin; Auflage: 4., aktualis., korrig. u. erg. A. (25. August 2009), ISBN-10: 9783540282044, ISBN-13: 978-3540282044

Gasch, Robert: Windkraftanlagen, Teubner B.G. GmbH; 4. Auflage, Dezember 2005, ISBN-10: 3519363348, ISBN-13: 978-3519363347

Gasch, Robert, Jochen Twele: Wind Power Plants, Fundamentals, Design, Construction and Operation. ISBN: 978-3-642-22937-4 (Print) 978-3-642-22938-1

Charlier, R.H. and Finkl, C.W.: Ocean Energy – Tide and Tidal Power; Springer Verlag Berlin / Heidelberg 2009, ISBN 978-3-540-77932-2

Ross, David: Power from the Waves; Oxford University Press, 1995, ISBN 0-19-856511-9

McCormick, Michael E.: Ocean Wave Energy Conversion, Dover Publications Inc., Mineola, New York 2007; ISBN 978-0-486-46245-5

Arthur Pecher, Jens Peter Kofoed, Editors: Handbook of Ocean Wave Energy, Springer Open, Ocean Engineering & Oceanography ISBN 978-3-319-39888-4 ISBN 978-3-319-39889-1 (eBook)

**Responsible for Module:**

Tobias Liepert (tobias.liepert@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU54009: Flood Risk and Flood Management | Hochwasserrisiko und Hochwassermanagement [FRM]

Version of module description: Gültig ab winterterm 2021/22

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination is a 120-minute written test. Only permitted aid is non-programmable calculator. The necessary mathematical formulas are given on the test sheets.

In the written exam, the students demonstrate that they can explain the concepts of hydrological floodwater modeling and flood risk management, taking into account the legal framework as well as social boundary conditions. Through practical tasks on typical flood events, they demonstrate that they can apply quantitative methods for damage and risk assessment, as well as perform risk-based assessment and sensitivity analysis of the effectiveness of flood protection measures.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamentals of hydrology (e.g. Hydrology Basic Module (BGU54006), bachelor program Umweltingenieurwesen, TUM),

Fundamentals of probability theory and risk analysis (e.g. Environmental Monitoring and Risk Management (BGU54007 or BGU54025), bachelor program Umweltingenieurwesen, TUM),  
Fundamentals of programming in Matlab

#### Content:

First the general motivation of flood risk management (FRM), the social and political framework of FRM as well as tools and models for the hydrologic/hydraulic modelling of the flood events are provided. Also different strategies and measures of technical and decentral flood protection are included. In the second part of the course, quantitative methods for analyzing the flood damage and flood risk and for risk-based evaluation/optimization of the flood protection measures. The accompanying exercises will provide brief summary of programming in MATLAB and the students

will learn how to implement the theory explained in the lectures on simple but realistic examples using Matlab and the water balance model LARSIM, which is used wide spread in Middle Europe for flood forecasts.

#### Lecture

- Safety, security, and risk
- The risk management cycle
- Qualitative and quantitative methods for flood risk assessment
- Planning of flood protection measures: determination of design values
- Flood frequency statistic base on gauged data
- Contents and significance of the EU directive on the assessment and management of flood risks
- Overview of technical and decentral flood protection measures
- Failure of flood protection measures
- Flood hazard scenarios
- Risk and risk acceptance: Communication of risks and legal aspects.

#### Exercise

- LARSIM: Understanding and dealing with the water balance model LARSIM in reasons of flood forecast and river basin modelling.

#### Quantitative risk assessment: lecture and exercise

- Decision-making, risk acceptance, optimization of mitigation measures
- Flood damage assessment
- Risk quantification
- Uncertainty quantification, sensitivity analysis
- Issues of long-term planning: non-stationarity, adaptability

#### **Intended Learning Outcomes:**

After completing the module, the students are able to:

- Understand the basic concepts of flood risk management as well as its legal and social framework,
- to apply methods for the hydrological modeling of flood events;
- to apply quantitative methods for general risk assessment and damage assessment as well as for specific flood risks
- evaluate and select the effectiveness of flood protection measures.
- to apply sensitivity analysis
- to use the MATLAB programming in the specific field of flood risk management.
- to use the hydrological water balance model LARSIM to solve questions of flood prediction.
- to structure and implement the theoretical and mathematical concepts in calculation algorithms.

#### **Teaching and Learning Methods:**

The module consists of lectures with integrated exercises.

The theoretical basics are presented through a lecture series. The students are encouraged to study the recommended literature and deepen their knowledge in certain topics. Computer

exercises based on practical problems are solved by the students. They sharpen their technical skills in dealing with MATLAB and LARSIM. The exercises are individual or group work. Voluntary homework tasks, which are to be worked in groups,

**Media:**

Power-Point-Presentation,  
Blackboard,  
Computer lab

**Reading List:**

The documents and resources listed below are some examples for your interest:

Flood Manager E-Learning (TU Hamburg-Harburg): <http://daad.wb.tu-harburg.de/homepage/>

Merz, B., J. Hall, M. Disse, and A. Schumann. "Fluvial Flood Risk Management in a Changing World." *Natural Hazards and Earth System Science* 10, no. 3 (March 16, 2010): 509–527. doi:10.5194/nhess-10-509-2010.

Rogger, M., Kohl, B., Pirkl, H., Viglione, A., Komma, J., Kimbauer, R., Merz, R., Blöschl, G., 2012. Runoff models and flood frequency statistics for design flood estimation in Austria – Do they tell a consistent story? *J. Hydrol.* 456–457, 30–43.^

Bründl, M., Romang, H.E., Bischof, N., Rheinberger, C.M., 2009. The risk concept and its application in natural hazard risk management in Switzerland. *Nat. Hazards Earth Syst. Sci.* 9, 801–813.

Pianosi, F., Wagener, T., Rougier, J., Freer, J., Hall, J., 2014. Sensitivity Analysis of Environmental Models: A Systematic Review with Practical Workflow, in: *Vulnerability, Uncertainty, and Risk*. American Society of Civil Engineers, pp. 290–299.

**Responsible for Module:**

Prof. Dr.-Ing. Markus Disse ([markus.disse@tum.de](mailto:markus.disse@tum.de))

**Courses (Type of course, Weekly hours per semester), Instructor:**

Flood Risk and Flood Management (Vorlesung mit integrierten Übungen, 4 SWS)

Disse M [L], Broich K, Disse M ( Broich K, Gerner A ), Gerner A

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU60013: Risk Assessment | Risikobewertung [RA2]

Version of module description: Gültig ab summerterm 2020

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>30   | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module exam is an oral examination of 40 minutes duration.

In the oral examination the student should be able to reflect and reproduce the contents of the course. The student will be given one problem that is oriented at the lectures as well as the homework and exercises throughout the semester. The student should study the problem and outline a solution during 15 minutes. Subsequently he/she will present his/her solution and answer follow-up questions. The students have to be able to describe and reflect important theories. Solutions will be discussed and examined during iterative rounds of questions. The oral examination enables the examiners to be responsive to the individual student and to evaluate the student's competences realistically.

The student can submit an assignment during the semester. Successful completion gives a bonus of 0.3 for the final grade.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The module will assume a basic knowledge of probability concepts such as random variables and their description (e.g., through completion of the BSc course "Zuverlässigkeit und Lastannahmen") [Modulnumber BV600003]. Basic Matlab knowledge is an advantage but not required (an introduction will be given).

#### Content:

1. Introduction, Data analysis using Matlab
2. Probability theory
3. Random variables

4. Parameter estimation
5. Probabilistic modeling of systems
6. Discrete probability models in engineering
7. Continuous probability models in engineering
8. Multivariate probability models
9. Functions of random variables
10. Monte Carlo simulation
11. Extreme value distributions
12. Random processes
13. Outlook

### **Intended Learning Outcomes:**

Students are able to understand concepts of uncertainty and information. Students gain a profound toolbox for analyzing engineering problems subject to uncertainty and randomness. At the end of the module, students are able to:

- Know when to apply probabilistic methods and risk analysis
- Use the appropriate probabilistic model for individual and groups of variables
- interpret data analysis (statistics) using Matlab
- Apply Bayes rule for information updating
- Analyze the reliability of systems with statistically dependent elements
- use functions of random variables
- create stochastic process models
- Interpret the quality of a probabilistic analysis

### **Teaching and Learning Methods:**

The module consist of weekly lectures with integrated exercises from the fields of civil, environmental, structural, and mechanical and transportation engineering.

Lectures will be given on the blackboard, including selected illustrations. Case studies should help the understanding of the problems. The lecture notes in PDF form will be distributed at the beginning of the semester.

Simple examples for hand-calculation will be provided within the lectures and more realistic examples will be carried out using Matlab in the computer facilities of the department.

Short tests (15min) will be carried out during the semester, which serve to self-assess the learning success of students.

### **Media:**

- Lectures with blackboard supported by PowerPoint
- Exercises, partly using Matlab (which is available to all TUM students)
- Lecture notes including theory and examples
- Short tests
- 2 homework examples

**Reading List:**

Lecture notes will be distributed. The following books provide useful supplemental material:

- Kottegod, N. T., and R. Rosso (2008), Applied statistics for civil and environmental engineers, Blackwell, Oxford.
- Ang, A. H.-S., and Tang, W. H. (2006). Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering, Wiley, New York.
- Benjamin, J. R., and C.A., C. (1970). Probability, Statistics and Decision for Civil Engineers, McGraw-Hill, New York.
- Bedford, T., and Cooke, R. (2001). Probabilistic risk analysis: foundations and methods, Cambridge University Press.

**Responsible for Module:**

Herr Prof. Dr. sc. Tech. Daniel Straub [straub@tum.de](mailto:straub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Risikobewertung (Vorlesung, 3 SWS)

Straub D, Teichgräber P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BGU60015: Reliability for Engineering Systems | Zuverlässigkeit von Systemen

*Reliability of engineering systems*

Version of module description: Gültig ab summerterm 2016

|                       |                             |                                  |                                      |
|-----------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b>  | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3 | <b>Total Hours:</b><br>120  | <b>Self-study Hours:</b><br>80   | <b>Contact Hours:</b><br>40          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

In the oral examination the student should be able to reflect and reproduce the contents of the course. The student will be given one problem that is oriented at the lectures as well as the homework and exercises throughout the semester. The student should study the problem and outline a solution during 15 minutes. Subsequently he/she will present his/her solution and answer follow-up questions. The students have to be able to describe and reflect important theories. Solutions will be discussed and examined during iterative rounds of questions. The oral examination enables the examiners to be responsive to the individual student and to evaluate the student's competences realistically.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Risk Analysis 1

#### Content:

1. General introduction and brief review of course prerequisites
2. Binary system models
3. Fault tree and event tree analysis
4. Dependent failures
5. Physically-based system models
6. Sampling-based system reliability
7. Performance and sensitivity measures



**Intended Learning Outcomes:**

This course enables the student to analyze, manage and communicate the reliability of infrastructure, technical and environmental systems. Upon completion of the course, students will be able to:

- Select appropriate system models for reliability assessment.
- Utilize traditional tools for system reliability and risk analysis, such as fault and event trees.
- Model complex engineering systems through sampling based methods.
- Compute system failure probabilities
- Model and assess the effect of dependence among system components
- Identify important components and failure modes in systems.
- Implement the methods in computational tools such as Matlab

**Teaching and Learning Methods:**

The course will consist of lectures, including application examples, and exercises from the fields of civil, environmental, structural and transportation engineering.

Lectures will be given on the blackboard and through slides. Case studies should help the understanding of the problems. The lecture notes in PDF form will be distributed at the beginning of the semester.

Homework will be provided but is not compulsory.

**Media:**

- Lectures with blackboard supported by slides
- Supervised study
- Lecture notes including theory and examples
- Optional homework examples

**Reading List:**

Bedford, T., and Cooke, R. (2001). Probabilistic risk analysis: foundations and methods, Cambridge University Press.

**Responsible for Module:**

Prof. Daniel Straub [straub@tum.de](mailto:straub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Zuverlässigkeit von Systemen (Vorlesung, 2 SWS)

Straub D, Teichgräber P

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV170009: International Water Rights and Politics | Internationales Wasserrecht [GRAMBOW]**

Version of module description: Gültig ab winterterm 2020/21

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The exam in this module is a final written exam (60 min) in which the students have to answer questions in the field of water rights and regulations in an international context.

The comprehension of the lecture contents is also checked by some transfer questions, which are oriented on the presented exemplary areas of application. With the written examination, students demonstrate that they understand the meaning of water for the global development, have knowledge in water rights and regulations in an international context and are able to use sustainable approaches to solve challenges of worldwide water law.

In addition to the final exam, students have the possibility to hold a mid-term presentation of 10-15 min presenting a topic linked to the course content. The presentation will be assessed in a pass/fail mode according to the content of the presentation and the presentation style. By passing the mid-term presentation, students will be awarded a 0.3 bonus on the grade of the final exam. With the mid-term presentation, students demonstrate that they have analyzed a water policy related problem in detail, can assess and evaluate it against the background of international water policy, and can present their summarized results to their fellow students.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Bachelor in Civil Engineering or Environmental Engineering

#### **Content:**

The world water situation is critical. In a first part this is illustrated by showing examples and discussions of international indicators. This should provide the necessary understanding, how policy and law affect this development of problems;

Part two of the course discusses detailed the principles of solutions, which the world has described in the Agenda 21, the approach of Sustainability and the derived Integrated Water Resource Management (IWRM). The basics of good water governance (law and policy) are worked out by introducing the handling of complex structures and check lists like the ten principles of sustainability. This is spiced by enhanced administrative tools and basics of state philosophy. Part three shows and discusses practical solutions: EU- Water Frame Directive; basics of water law at the example of the German WHG and the Bavarian BayWG, Water Policy and Good Governance in practice and the strategy of implementation. The whole lecture includes a discussion of concrete examples from all over the world, delivered by the teacher and the students.

### **Intended Learning Outcomes:**

After completion of the module students will be able to understand the meaning of water for the global development and the multi-dependent system of world environment. They will also understand the important role and principle of sustainability. They will be able to use the sustainable approach for design and construction including balancing the aspects of economy, ecology and social effects and also the usage of integrality (IWRM) and the approaches of efficiency and sufficiency.

They will know the basic lines of good water policy and good governance understand the challenges and principles of worldwide water law.

### **Teaching and Learning Methods:**

In order to complete the module successfully, the knowledge transfer must take place predominantly by practical examples. These examples are provided through a slide presentation. Where possible, also video clips are presented to make contents more clear.

### **Media:**

PowerPoint Presentation and Script

### **Reading List:**

### **Responsible for Module:**

Yannic Fuchs (yannic.fuchs@tum.de)

### **Courses (Type of course, Weekly hours per semester), Instructor:**

Internationale Wasserpolitik und Recht (Vorlesung, 2 SWS)

Grambow M ( Fuchs Y ), Fuchs Y

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV180006: Hydrochemistry | Hydrochemie

Version of module description: Gültig ab winterterm 2018/19

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The written exam (60 min) consists of general questions and calculations. With the exam students demonstrate that they understand basics and specific interactions of water and hydrochemistry. theoretical knowledge of hydrochemistry, can analyse redox reactions and corrosion processes and are able to develop treatment concepts for specific water contaminants.

The exam is a mix of open questions requiring own descriptions, multiple choice tests and chemical calculations. The use of a calculator is allowed in the written exam

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic knowledge of inorganic and organic chemistry from the 2nd and 3rd semester BSc. environmental engineering are necessary to follow lectures

#### Content:

In the lecture the scope of hydrochemistry, water cycle, chemical thermodynamics and reactions are discussed. Acids and bases, dissolved carbon dioxide and the carbonate equilibria are presented. Precipitation and dissolution, oxidation and reduction reactions are content of the course as well as redox and corrosion processes. Furthermore natural and anthropogenic substances and their influences on the chemical composition of natural waters are shown.

#### Intended Learning Outcomes:

After completion of the module, the students are able to describe the basics and interactions of important water properties and contents. They can apply redox reactions and analyze corrosion processes. They are further able to evaluate geogenic and anthropogenic water contents and to develop specific methods for treatment.

**Teaching and Learning Methods:**

The module consists of a lecture series. Presentations during the lectures provide the theoretical basis on water chemistry. Understanding of chemical calculations will be supported in small exercises based on relevant practical applications.

**Media:**

Beamer, board

**Reading List:**

Stumm, W., Morgan, J.J.: Aquatic Chemistry. John Wiley & Sons, 1996, 3rd ed., ISBN: 0-471-51184-6

Grohmann, A.N., Jekel, M., Grohmann, A., Szewzyk, R., Szewzyk, U.: Wasser. De Gruyter Verlag, 2011, ISBN 978-3-11-021308-9

Reemtsma, T., Jekel, M.: Organic Pollutants in the Water Cycle. Wiley-VCH, Weinheim, ISBN-10: 3-527-31297-8

**Responsible for Module:**

Apl. Prof. Dr. Brigitte Helmreich (b.helmreich@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Hydrochemistry (Vorlesung, 2 SWS)

Helmreich B [L], Helmreich B

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV380004: Microbiology of Groundwater Ecosystems | Mikrobiologie von Grundwasserökosystemen**

Version of module description: Gültig ab summerterm 2011

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

written exam

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Basics in ecology and Microbiology

#### **Content:**

The course consists of an

-introduction to Groundwater ecosystems

" what makes them different

" porous vs. karst and fissured systems

" Organismic repertoire

" Energetic constraints

" Heterotrophy vs. Autotrophy

" Case study: lithoautotrophic ecosystems in caves (Frassassi, Movile)

-Microbiological basics - FAQs

" How is a bacterial cell composed

" How to convert biomass in cells assimilation efficiencies

" Growth in the subsurface How fast do microbes reproduce

" Transport and Migration rates - How fast can a bacterium swim

-Microbes in groundwater and aquifers

" The limits for life

- " Spatial and temporal distribution
- " Sessile vs. attached
- " Are there biofilms in aquifers?
- " Dormant vs. active
- " Case study: Distribution of bacteria in a pristine (Anif) and a contaminated (Flingern) aquifers

-Viruses in the subsurface

- " What is a virus
- " Natural and pathogenic viruses
- " Lytic vs. lysogenic viruses
- " The viral shunt component of the microbial food web
- " Viral control of microbial activities
- " Case study: The granitic aquifer of the ASPÖ hard rock lab in Sweden

-Microbial diversity in the subsurface

- " Conceptual frameworks
- " Methods to study microbial diversity
- " Driving forces
- " Case study: Selected hydrocarbon contaminated aquifers

-Microbial activity in the subsurface

- " Aerobic vs. anaerobic mode of living
- " Important anaerobic respirations
- " Thermodynamic constraints
- " Most important redox processes
- " Case study: The tar oil-contaminated aquifer in Flingern

-Trophic interactions in aquifers

- " Syntrophy, symbioses
- " Microbial food webs and trophic channels
- " Protozoa, Fungi
- " Groundwater Fauna
- " Case study: The karst systems of the Rax and Schnealpe

-Groundwater ecosystem services

- " Water purification and drinking water production
- " Biodegradation
- " Water balancing and GW dependent ecosystems
- " Microbes as bioindicators
- " Development of ecological sound assessment schemes
- " Case study: The UBA project

-Groundwater contamination and microbial biodegradation

- " Priority contaminants in groundwater

- " Future contaminants
- " Groundwater legislation and EU-WFD
- " What is degradable and what not?
- " Case study: Aromatic hydrocarbons
  
- Characterization of microbial communities
  - " Molecular community analyses
  - " Identification of key-players
  - " Determination of in situ activities
  - " Labelling as a tool to identify key-processes
  
- Life in the deep subsurface
  - " Is there life independent from land surface?
  - " Radiolysis, geogenic electron donors
  - " Microbiology of deep geothermal waters
  
- (Bio)Remediation strategies for contaminated groundwater
  - " Injection of electron acceptors / donors
  - " Bioaugmentation
  - " Reactive barriers
  - " Monitoring of natural attenuation

This module can be seen as an advanced class building up partly on the lectures on 'Basics of Ecology' and 'Microbiology'.

#### **Intended Learning Outcomes:**

Students are able to estimate the microbiology and biogeochemistry of groundwater ecosystems, which is essential for the understanding of subsurface processes including formation of geological units as well as the transport and degradation of contaminants.

#### **Teaching and Learning Methods:**

Teaching methods will include, besides the classical presentation mode, interactive work ( e.g. discussion individual tasks and working on exercises in small groups). Students will be actively integrated in the teaching and learning process applying state of the art educational tools. Applied exercises related to daily life problems and short movies will complement the lectures.

#### **Media:**

Beamer, handouts

#### **Reading List:**

Chappelle, F.H. (2000) Ground-Water Microbiology and Geochemistry, Wiley; Griebler, C. & Mösslacher, F. (2003) Grundwasser-Ökologie, UTB-Facultas, Wien. Specific literature will be distributed in form of scientific articles.



**Responsible for Module:**

Brigitte Helmreich (b.helmreich@bv.tu-muenchen.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### **BV470017: Advanced GIS for Environmental Engineering - Applications | Advanced GIS für Umweltingenieure - Anwendungen**

Version of module description: Gültig ab summerterm 2020

|                                |                                    |                                  |                                      |
|--------------------------------|------------------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90          | <b>Self-study Hours:</b><br>75   | <b>Contact Hours:</b><br>15          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

The expected learning outcomes are verified as follows: with two oral presentations (mid-term and at the end of the module (30%)) and a written report (70%) which cover the project work. Students work on the project in their self-study hours. A weekly meeting is scheduled with the supervisors of the project. The students have to document that they are able to solve a problem from the field of Geoinformatics independently and that they are able to present their solutions orally as well as in written form.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

Prerequisites are fundamentals in Geoinformatics.

#### **Content:**

Contents:

Deepening the knowledge in Geoinformatics through self-contained project work, optionally with participation of industry or administration. Solving applied or research oriented problems from the Geoinformatics domain.

**Intended Learning Outcomes:**

At the end of the module students are able: to develop concepts for implementation projects in the field of Geoinformatics.

**Teaching and Learning Methods:**

Project work, self-contained solving of a problem from the Geoinformatics domain, supervised by a member of the academic staff. Presentation skills shall be practiced by giving a mid-term and a final presentation of the project work.

**Media:**

Presentations,  
simulation-, GIS- und database software.

**Reading List:**

The supervisor of the project work provides literature.

**Responsible for Module:**

Kolbe, Thomas; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Geoinformatik 3 (Vorlesung, 3 SWS)

Donaubauer A ( Willenborg B ), Kolbe T

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### BV470018: Spatiotemporal Analyses in GIS | Raumzeitliche Analyse in GIS

Version of module description: Gültig ab summerterm 2020

|                                |                            |                                  |                                      |
|--------------------------------|----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90  | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

Goal of the written exam (duration: 60 Minutes) is to assess that the students understand methods to develop a spatio-temporal information system. Therefore problems have to be analyzed in limited time and, based upon the learning outcomes acquired in this module, solutions have to be found and implemented. The answers are partly own formulations and partly multiple-choice with an emphasis on short programming tasks.

Participants are not allowed to use any technical aids and auxiliary material during the exam.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Fundamentals of geographic information systems as taught in the Bachelor courses GIS 1 and 2, or proof of equivalent knowledge.

#### Content:

- Data preparation (Java excel API)
- Data modeling (SQL)
- Data base: Oracle XE (data type: SDO)

- User interface(PHP, HTML)
- Apache web server
- Installation of GeoServer
- Configuration of a web map service
- Geostatistical methods (ESRI + own service)
- Spatiotemporal analysis

### **Intended Learning Outcomes:**

At the end of the module students are able to develop a geographic information system for spatio-temporal issues. They can develop a closed system for displaying location-based data and thus provide the technical basis for answering spatial research questions.

### **Teaching and Learning Methods:**

The module combines elements of a lecture with those of an exercise course. The fundamentals are taught teacher-centered by power point and back board work. In the exercise course this new skills are consolidated in team and individual work. Thereto guided assignments have to be solved. There are transfer task to ensure interdisciplinary skills and expertise. The exercise and lecture materials are provided in a comprehensive wiki.

### **Media:**

- PowerPoint
- Wiki
- Black board
- Blog
- Data base, GIS software

### **Reading List:**

- ULLENBOOM, Ch., 2006: Java ist auch eine Insel Das umfassende Handbuch Programmieren mit der Java Standard Edition Version 5.5., aktualisierte und erweiterte Auflage, 1. Nachdruck 2006, Bonn, 1456 S.
- Open Geospatial Consortium, 2004: OGC Web Map Service Interface Version 1.3.0
- GeoServer User Manual (online unter: [www.geoserver.org](http://www.geoserver.org))
- course wiki (access informatio is provided in the first lesson)

### **Responsible for Module:**

Thomas H. Kolbe ([thomas.kolbe@tum.de](mailto:thomas.kolbe@tum.de))

### **Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](#).

## Module Description

### BV600001: Risk Analysis | Risikoanalyse [RA1]

Version of module description: Gültig ab summerterm 2021

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>6          | <b>Total Hours:</b><br>180  | <b>Self-study Hours:</b><br>120  | <b>Contact Hours:</b><br>60          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of a Klausur (duration 90 min).

With the exam the students prove that they are able to reflect and reproduce the contents of the modul. Also the Students demonstrate that they are able to describe and reflect important theories. Throughout the semester, students are given tasks based on the lectures, as well as homework and exercises to continuously check their level of knowledge.

All study materials, literature and simple scientific calculators are permitted as aids in the exam.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

The module will assume a basic knowledge of probability concepts such as random variables and their description (e.g., through completion of the BSc course "Zuverlässigkeit und Lastannahmen") [Modulnummer BV600003]. Basic Matlab knowledge is an advantage but not required (an introduction will be given).

#### Content:

1. Introduction, Data analysis using Matlab
2. Probability theory
3. Random variables
4. Parameter estimation
5. Probabilistic modeling of systems
6. Discrete probability models in engineering
7. Continuous probability models in engineering
8. Multivariate probability models

9. Functions of random variables
10. Monte Carlo simulation
11. Extreme value distributions
12. Random processes
13. Outlook

**Intended Learning Outcomes:**

After participation in the module students are able to understand concepts of uncertainty and information. Students gain a profound toolbox for analyzing engineering problems subject to uncertainty and randomness. At the end of the module, students are able to:

- Know when to apply probabilistic methods and risk analysis
- Use the appropriate probabilistic model for individual and groups of variables
- interpret data analysis (statistics) using Matlab
- Apply Bayes rule for information updating
- Analyze the reliability of systems with statistically dependent elements
- use functions of random variables
- create stochastic process models
- Interpret the quality of a probabilistic analysis

**Teaching and Learning Methods:**

The module consist of weekly lectures with integrated exercises from the fields of civil, environmental, structural, and mechanical and transportation engineering.

Lectures will be given on the blackboard, including selected illustrations. Case studies should help the understanding of the problems. The lecture notes in PDF form will be distributed at the beginning of the semester.

Simple examples for hand-calculation will be provided within the lectures and more realistic examples will be carried out using Matlab in the computer facilities of the department.

Short tests (15min) will be carried out during the semester, which serve to self-assess the learning success of students.

**Media:**

- Lectures with blackboard supported by PowerPoint
- Exercises, partly using Matlab (which is available to all TUM students)
- Lecture notes including theory and examples
- Short tests
- 2 homework examples

**Reading List:**

Lecture notes will be distributed. The following books provide useful supplemental material:

- Kottegod, N. T., and R. Rosso (2008), Applied statistics for civil and environmental engineers, Blackwell, Oxford.
- Ang, A. H.-S., and Tang, W. H. (2006). Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering, Wiley, New York.

- Benjamin, J. R., and C.A., C. (1970). Probability, Statistics and Decision for Civil Engineers, McGraw-Hill, New York.
- Bedford, T., and Cooke, R. (2001). Probabilistic risk analysis: foundations and methods, Cambridge University Press.

**Responsible for Module:**

Herr Prof. Dr. sc. Tech. Daniel Straub [straub@tum.de](mailto:straub@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

Risikoanalyse (Vorlesung mit integrierten Übungen, 4 SWS)

Straub D [L], Straub D, Bismut E

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Module Description

### MW1475: Renewable Energy Technology 1 | Regenerative Energiesysteme 1 [RET I]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam takes 60 minutes and consists of a number of short questions on certain aspects of the topics presented as well as some calculations. Allowed auxiliary are writing and drawing utensils and a non programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic thermodynamics and fluid dynamics

#### Content:

Content:

This course offers an insight into renewable energy sources, and the existing technologies to use them. It also looks to present the political framework of renewable energy technology, as well as societal and ecological aspects from a global point of view. The course is recommended for students not majoring in the field, who are interested in gaining an overview of renewable energy systems.

The course RENEWABLE ENERGY TECHNOLOGY (taught in English) is split into two modules 3 ECTS each (one per semester), beginning with "RET I" in the Winter Semester. The attached module "RET II" will be offered in the Summer Semester.

The course is supported by various institutions of the TUM: The Institute for Energy Systems, the Institute for Renewable and Sustainable Energies, The Institute for Wind Energy, The chair of Hydraulic and Water Resources Engineering as well as the "Laboratory of Steam Boilers and Thermal Plants" from the National Technical University of Athens.

The module "RET I" covers the following topics:

- Fundamentals
- Energy from Biomass
- Geothermal Energy
- Wind Energy

In the module "RET II" the following topics are covered:

- Hydropower
- Solar Thermal Energy
- Photovoltaics

From the winter semester 2017/2018 onwards  
the module "RET I" covers the following topics:

- Fundamentals
- Energy from Biomass
- Geothermal Energy
- Hydropower

whereas the module "RET II " is composed as follows:

- Wind Energy
- Solar Thermal Energy
- Photovoltaics

### **Intended Learning Outcomes:**

After the participation in the module the students are able to understand the basics of the most relevant renewable energy technologies.

The gained knowledge enables the students to describe the fields of application as well as the limits of the presented renewable forms of energy. Moreover, the students are able to explain the elementary aspects of renewable energies from a physical, technical, and economical point of view.

They are familiar with technological solutions of all the presented renewable forms of energy and are able to classify their fields of application.

In addition, the students are able to identify the most suitable technology for a given field of application with particular focus on key physical, technical, and economical issues. In this context, the students are able to list and explain the environmental, economic, and social impacts of the selected technology.

### **Teaching and Learning Methods:**

90 min lecture including discussion on the current topic per week. Students are encouraged to take part in the discussion and to question the arguments given by the lecturer. Autonomous preparing at home is needed to fully understand the learning matter.

### **Media:**

Powerpoint presentations

**Reading List:**

German Literature:

Kaltschmitt, Martin: Erneuerbare Energien. Springer Verlag, Berlin

Quaschnig, Volker: Regenerative Energiesysteme. Technologie - Berechnung - Simulation. Carl Hanser Verlag, München

Heliß, Michael: Regenerative Energiequellen. Praktikum. Springer Verlag, Berlin

Mohr, Markus: Chancen erneuerbarer Energiequellen. Springer Verlag, Berlin

English Literature:

Spliethoff, Hartmut: Power Generation from Solid Fuels. Springer Verlag, Berlin

Boyle: Renewable Energy. Oxford University Press

Kaltschmitt, Martin: Renewable Energy: Technological Foundations, Economical and Environmental Aspects. Springer Verlag, Berlin

Wengenmayr, Roland: Renewable Energy: Sustainable Energy Concepts for the Future. Wiley-VCH Verlag

International Energy Agency: Energy Technology Perspectives - Scenarios & Strategies to 2050

International Energy Agency: World Energy Outlook

**Responsible for Module:**

Spliethoff, Hartmut; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Regenerative Energiesysteme I (Vorlesung, 2 SWS)

Roeder G [L], Spliethoff H, Kunze C, Roeder G, Wieland C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Module Description

### MW1476: Renewable Energy Technology 2 | Regenerative Energiesysteme 2 [RET II]

Version of module description: Gültig ab winterterm 2020/21

|                                |                             |                                  |                                      |
|--------------------------------|-----------------------------|----------------------------------|--------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>summer semester |
| <b>Credits:*</b><br>3          | <b>Total Hours:</b><br>90   | <b>Self-study Hours:</b><br>60   | <b>Contact Hours:</b><br>30          |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The exam takes 60 minutes and consists of a number of short questions on certain aspects of the topics presented as well as some calculations. Allowed auxiliary are writing and drawing utensils and a non programmable calculator.

#### Repeat Examination:

Next semester

#### (Recommended) Prerequisites:

Basic thermodynamics and fluid dynamics.

#### Content:

Content:

This course offers an insight into renewable energy sources, and the existing technologies to use them. It also looks to present the political framework of renewable energy technology, as well as societal and ecological aspects from a global point of view. The course is recommended for students not majoring in the field, who are interested in gaining an overview of renewable energy systems.

The course RENEWABLE ENERGY TECHNOLOGY (taught in English) is split into two modules 3 ECTS each (one per semester), beginning with "RET I" in the Winter Semester. The attached module "RET II" will be offered in the Summer Semester.

The course is supported by various institutions of the TUM: The Institute for Energy Systems, the Institute for Renewable and Sustainable Energies, The Institute for Wind Energy, The chair of Hydraulic and Water Resources Engineering as well as the "Laboratory of Steam Boilers and Thermal Plants" from the National Technical University of Athens.

The module "RET I" covers the following topics:

- Fundamentals
- Energy from Biomass
- Geothermal Energy
- Wind Energy

In the module "RET II" the following topics are covered:

- Hydropower
- Solar Thermal Energy
- Photovoltaics

From the winter semester 2017/2018 onwards  
the module "RET I" covers the following topics:

- Fundamentals
- Energy from Biomass
- Geothermal Energy
- Hydropower

whereas the module "RET II " is composed as follows:

- Wind Energy
- Solar Thermal Energy
- Photovoltaics

### **Intended Learning Outcomes:**

After the participation in the module the students are able to understand the basics of the most relevant renewable energy technologies.

The gained knowledge enables the students to describe the fields of application as well as the limits of the presented renewable forms of energy. Moreover, the students are able to explain the elementary aspects of renewable energies from a physical, technical, and economical point of view.

They are familiar with technological solutions of all the presented renewable forms of energy and are able to classify their fields of application.

In addition, the students are able to identify the most suitable technology for a given field of application with particular focus on key physical, technical, and economical issues. In this context, the students are able to list and explain the environmental, economic, and social impacts of the selected technology.

### **Teaching and Learning Methods:**

90 min lecture including discussion on the current topic per week. Students are encouraged to take part in the discussion and to question the arguments given by the lecturer. Autonomous preparing at home is needed to fully understand the learning matter.

**Media:**

Powerpoint presentations

**Reading List:**

German Literature:

Kaltschmitt, Martin: Erneuerbare Energien. Springer Verlag, Berlin

Quaschnig, Volker: Regenerative Energiesysteme. Technologie - Berechnung - Simulation. Carl Hanser Verlag, München

Heliß, Michael: Regenerative Energiequellen. Praktikum. Springer Verlag, Berlin

Mohr, Markus: Chancen erneuerbarer Energiequellen. Springer Verlag, Berlin

English Literature:

Spliethoff, Hartmut: Power Generation from Solid Fuels. Springer Verlag, Berlin

Boyle: Renewable Energy. Oxford University Press

Kaltschmitt, Martin: Renewable Energy: Technological Foundations, Economical and Environmental Aspects. Springer Verlag, Berlin

Wengenmayr, Roland: Renewable Energy: Sustainable Energy Concepts for the Future. Wiley-VCH Verlag

International Energy Agency: Energy Technology Perspectives - Scenarios & Strategies to 2050

International Energy Agency: World Energy Outlook

**Responsible for Module:**

Spliethoff, Hartmut; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**

Regenerative Energiesysteme II (Vorlesung, 2 SWS)

Roeder G [L], Hamacher T, Bottasso C, Breuning L, Roeder G, Sucameli C, Vannahme A, Wieland C

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

## Project Studies | Projektstudium

### Module Description

#### **BGU900035: Partner University DTU - Project Studies | Partneruniversität DTU - Projektstudium**

Version of module description: Gültig ab summerterm 2016

|                        |                     |                          |                       |
|------------------------|---------------------|--------------------------|-----------------------|
| <b>Module Level:</b>   | <b>Language:</b>    | <b>Duration:</b>         | <b>Frequency:</b>     |
| <b>Credits:*</b><br>15 | <b>Total Hours:</b> | <b>Self-study Hours:</b> | <b>Contact Hours:</b> |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### **Description of Examination Method:**

#### **Repeat Examination:**

#### **(Recommended) Prerequisites:**

#### **Content:**

#### **Intended Learning Outcomes:**

#### **Teaching and Learning Methods:**

#### **Media:**

#### **Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).



## Master's Thesis | Master Thesis

### Module Description

#### BV00MTUI: Master's Thesis | Master's Thesis

Version of module description: Gültig ab summerterm 2018

|                                |                                    |                                  |                                             |
|--------------------------------|------------------------------------|----------------------------------|---------------------------------------------|
| <b>Module Level:</b><br>Master | <b>Language:</b><br>German/English | <b>Duration:</b><br>one semester | <b>Frequency:</b><br>winter/summer semester |
| <b>Credits:*</b><br>30         | <b>Total Hours:</b><br>900         | <b>Self-study Hours:</b><br>900  | <b>Contact Hours:</b>                       |

Number of credits may vary according to degree program. Please see Transcript of Records.

#### Description of Examination Method:

The module examination consists of the following parts:

- Scientific write-up of the Master's Thesis: The student proves ability to individually solve a problem within the field of the Master' Degree by creating individual concepts and conducting hands-on research (100% of module grade).
- Final presentation: With the final presentation the student proves the ability to present, reflect, and discuss methods and results in a structured way (pass/fail credit requirement, has to be passed)

#### Repeat Examination:

#### (Recommended) Prerequisites:

Permit of the board of examiners, proofing a sufficient study progress according to the exam regulations

#### Content:

Every student self-responsibly works with scientific methods on an individual research topic as agreed with the scientific examiner of the department of their studies that deals with a problem within the field of the Master's Degree.

**Intended Learning Outcomes:**

After successful completion of the module, students are able to define a scientific problem within the field of the Master's Degree or categorize a problem within existing theories. They are able to identify, discuss, and apply suitable methods to the problem out of the methods learned during studies, they can compile these methods to a methodology matching their topic, they can critically analyse the results and draw conclusions. They do so by independently researching and analysing relevant literature. The abilities include discussion and presentation of results with both supervisor and interested audience, drawing conclusions, and setting and following a timeline or project plan within the given deadlines.

**Teaching and Learning Methods:**

During the participation in the module the students practice the application of scientific methods in engineering. The Master's Thesis has the format of a research work that not only contains manual tasks and calculations, but also planning, composition of methodologies and conceptual elements that are part of the work scope in professional and scientific engineering life.

Every participant works on an individual topic related to a thematic part of the programme, in an independent way.

Every participant is assigned a scientific advisor matching the topic. The advisor assists especially during the early stage of the work, by presenting the technical background of the topic, assisting in the identification of relevant literature and by giving helpful hints both during the technical work and during the creation of the written documentation and presentation.

**Media:**

Self-study / practical work under the guidance of a scientific examiner

**Reading List:**

suitable Literature for chosen Topics

**Responsible for Module:**

Studiendekan

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).

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| <b>[BGU50008] Geotechnical Issues in Environmental Engineering</b>  <br>Geotechnische Fragestellungen im Umweltingenieurwesen                                                                                                                     | 624 - 626   |
| <b>[BV470002] Geo Web Services</b>   Geo Web Services                                                                                                                                                                                             | 1234 - 1235 |
| <b>[SZ0303] German as a Foreign Language A2.1</b>   Deutsch als Fremdsprache<br>A2.1                                                                                                                                                              | 1000 - 1001 |
| <b>[SZ0322] German as a Foreign Language A2.1 plus A2.2</b>   Deutsch als<br>Fremdsprache A2.1 plus A2.2                                                                                                                                          | 1011 - 1012 |
| <b>[SZ0304] German as a Foreign Language A2.2</b>   Deutsch als Fremdsprache<br>A2.2                                                                                                                                                              | 1004 - 1005 |
| <b>[SZ0332] German as a Foreign Language B2+C1 - Intercultural<br/>Communication Skills - "Working as an Engineer in Germany"</b>   Deutsch<br>als Fremdsprache B2+C1: Interkulturelle Kommunikation - Als IngenieurIn in<br>Deutschland arbeiten | 1015 - 1016 |
| <b>[SZ0314] German as a Foreign Language B2+C1: Kommunikation at<br/>work: German for Internship and Job</b>   Deutsch als Fremdsprache B2+C1:<br>Kommunikation am Arbeitsplatz: Deutsch für Praktikum und Beruf                                  | 1008 - 1010 |
| <b>[SZ0331] German for Engineers C1</b>   Deutsch für Ingenieur/innen C1                                                                                                                                                                          | 1013 - 1014 |
| <b>[CLA20710] Global Diversity Training</b>   Global Diversity Training                                                                                                                                                                           | 931 - 932   |
| <b>[BV560011] Governance</b>   Governance                                                                                                                                                                                                         | 362 - 364   |
| <b>[BV560011] Governance</b>   Governance                                                                                                                                                                                                         | 882 - 884   |
| <b>[BGU66022] Groundwater Hydraulics</b>   Grundwasserhydraulik                                                                                                                                                                                   | 147 - 149   |
| <b>[BGU66022] Groundwater Hydraulics</b>   Grundwasserhydraulik                                                                                                                                                                                   | 690 - 692   |
| <b>[BGU54010] Groundwater Hydraulics, Modelling and Management</b>  <br>Grundwasser - Hydraulik, Modellierung und Management [GHMM]                                                                                                               | 638 - 640   |
| <b>[BGU50007] Ground Water Handling and Sustainable Use of Geomaterials<br/>in Civil Construction</b>   Grundwassermanagement und nachhaltige<br>Materialverwendung in der Geotechnik                                                             | 248 - 250   |
| <b>[BGU50007] Ground Water Handling and Sustainable Use of Geomaterials<br/>in Civil Construction</b>   Grundwassermanagement und nachhaltige<br>Materialverwendung in der Geotechnik                                                             | 621 - 623   |

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| <b>[BV470003] Harmonisation of Geospatial Data</b>   Geodatenharmonisierung | 1236 - 1237 |
| <b>[BGU46022] Hydraulics in Water Engineering</b>   Wasserbauhydraulik [HE] | 586 - 587   |

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| <b>[BGU46032] Hydraulics in Water Engineering Laboratory</b>   Laborübung<br>Wasserbauhydraulik [HWEL]                                                                                                                                                            | 122 - 123   |
| <b>[BGU46032] Hydraulics in Water Engineering Laboratory</b>   Laborübung<br>Wasserbauhydraulik [HWEL]                                                                                                                                                            | 596 - 597   |
| <b>[BGU46032] Hydraulics in Water Engineering Laboratory</b>   Laborübung<br>Wasserbauhydraulik [HWEL]                                                                                                                                                            | 1305 - 1306 |
| <b>[BV410005] Hydraulics Lab</b>   Hydraulik Praktikum                                                                                                                                                                                                            | 213 - 214   |
| <b>[BV410005] Hydraulics Lab</b>   Hydraulik Praktikum                                                                                                                                                                                                            | 835 - 836   |
| <b>[BGU46035] Hydraulic Engineering and Hydromorphology</b>  <br>Wasserbauhydraulik und Hydromorphologie [HEHM]                                                                                                                                                   | 110 - 112   |
| <b>[BGU46035] Hydraulic Engineering and Hydromorphology</b>  <br>Wasserbauhydraulik und Hydromorphologie [HEHM]                                                                                                                                                   | 1309 - 1311 |
| <b>[BGU46034] Hydraulic Machinery and Plants Laboratory</b>   Laborübung<br>Hydraulische Maschinen und Anlagen                                                                                                                                                    | 126 - 127   |
| <b>[BGU46034] Hydraulic Machinery and Plants Laboratory</b>   Laborübung<br>Hydraulische Maschinen und Anlagen                                                                                                                                                    | 600 - 601   |
| <b>[BGU46034] Hydraulic Machinery and Plants Laboratory</b>   Laborübung<br>Hydraulische Maschinen und Anlagen                                                                                                                                                    | 1307 - 1308 |
| <b>[BV180006] Hydrochemistry</b>   Hydrochemie                                                                                                                                                                                                                    | 798 - 799   |
| <b>[BV180006] Hydrochemistry</b>   Hydrochemie                                                                                                                                                                                                                    | 1336 - 1337 |
| <b>[BV180051] Hydrochemistry Lab</b>   Hydrochemie Praktikum                                                                                                                                                                                                      | 56 - 57     |
| <b>[BV180051] Hydrochemistry Lab</b>   Hydrochemie Praktikum                                                                                                                                                                                                      | 802 - 803   |
| <b>[BGU57014] Hydrogeodesy: Monitoring surface waters from space</b>  <br>Hydrogeodäsie: Monitoring von Oberflächengewässern aus dem Weltraum                                                                                                                     | 97 - 99     |
| <b>[BGU66030] Hydrogeological and Isotopic Methods for the<br/>Characterization of Groundwater Systems for Environmental Engineers</b>  <br>Hydrogeologische und Isotopenchemische Methoden zur Charakterisierung von<br>Grundwassersystemen für Umweltingenieure | 166 - 169   |
| <b>[BGU66016] Hydrogeologic and Hydro Chemical Lab Course</b>  <br>Hydrogeologisches Fluid- und Hydrochemisches Laborpraktikum                                                                                                                                    | 687 - 689   |
| <b>[BGU54008T2] Hydrological and Environmental River Basin Modelling</b>  <br>Hydrologische und ökologische Flussgebietsmodellierung [HERBM]                                                                                                                      | 78 - 80     |
| <b>[BGU54008T2] Hydrological and Environmental River Basin Modelling</b>  <br>Hydrologische und ökologische Flussgebietsmodellierung [HERBM]                                                                                                                      | 187 - 189   |
| <b>[BGU54008T2] Hydrological and Environmental River Basin Modelling</b>  <br>Hydrologische und ökologische Flussgebietsmodellierung [HERBM]                                                                                                                      | 632 - 634   |
| <b>[BGU46021] Hydro Power and Energy Storage - Project Work</b>   Wasserkraft<br>und Energiespeicherung - Projektarbeit                                                                                                                                           | 584 - 585   |
| <b>[BV460017] Hydro Power and Energy Storage</b>   Wasserkraft und<br>Energiespeicherung [HPES]                                                                                                                                                                   | 859 - 860   |

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| <b>[BV410011] Hydro Project   Hydroprojekt</b>                                                                                                                    | 839 - 840   |
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| <b>[BGU68005] ICT-Enabled Business Models for Urban Mobility   ICT-unterstützte Unternehmensmodelle für urbane Mobilität [Business Models for Urban Mobility]</b> | 381 - 382   |
| <b>[BGU46041] Implementation of Water Policy and Water Legislation   Umsetzung von Wasserpolitik und Wassergesetzgebung [GRA_SEM]</b>                             | 128 - 130   |
| <b>[BGU46041] Implementation of Water Policy and Water Legislation   Umsetzung von Wasserpolitik und Wassergesetzgebung [GRA_SEM]</b>                             | 613 - 615   |
| <b>[CLA21213] Individual Change Management   Individual Change Management</b>                                                                                     | 937 - 938   |
| <b>[BGU38021] Industrial Wastewater Treatment and Reuse   Industrieabwasserreinigung und Wiederverwendung</b>                                                     | 37 - 38     |
| <b>[BGU38021] Industrial Wastewater Treatment and Reuse   Industrieabwasserreinigung und Wiederverwendung</b>                                                     | 557 - 558   |
| <b>[BGU38021] Industrial Wastewater Treatment and Reuse   Industrieabwasserreinigung und Wiederverwendung</b>                                                     | 1292 - 1293 |
| <b>[BV460019] Inland Navigation Management and Constructions   Verkehrswasserbau und Wasserstraßen</b>                                                            | 141 - 143   |
| <b>[BV460019] Inland Navigation Management and Constructions   Verkehrswasserbau und Wasserstraßen</b>                                                            | 863 - 865   |
| <b>[WI000285] Innovative Entrepreneurs - Leadership of High-Tech Companies   Innovative Unternehmer - Führung von High-Tech Unternehmen</b>                       | 471 - 473   |
| <b>[BV400021] Instruments of Land Mobilization   Instrumente der Bodenordnung und Landentwicklung</b>                                                             | 833 - 834   |
| <b>[WZ6108] Instruments of Spatial Planning   Planungsinstrumente der Landschaftsplanung</b>                                                                      | 1165 - 1167 |
| <b>[BV430002] Integral Transform Methods   Integraltransformationsmethoden</b>                                                                                    | 1228 - 1230 |
| <b>[BGU54011] Integrated Water Resources Management   Integriertes Wasserressourcen Management [IWRM]</b>                                                         | 70 - 72     |
| <b>[BGU54011] Integrated Water Resources Management   Integriertes Wasserressourcen Management [IWRM]</b>                                                         | 435 - 437   |
| <b>[BGU54011] Integrated Water Resources Management   Integriertes Wasserressourcen Management [IWRM]</b>                                                         | 641 - 643   |
| <b>[BV560023] Intelligent Transport Systems   Intelligente Verkehrssysteme [ITS]</b>                                                                              | 368 - 370   |
| <b>[BV560005] Intelligent Vehicles   Intelligente Fahrzeuge [IV]</b>                                                                                              | 880 - 881   |
| <b>[SZ03031] Intensive Course German as a Foreign Language A2.1   Blockkurs Deutsch als Fremdsprache A2.1</b>                                                     | 1002 - 1003 |
| <b>[SZ03041] Intensive Course German as a Foreign Language A2.2   Blockkurs Deutsch als Fremdsprache A2.2</b>                                                     | 1006 - 1007 |

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| <b>[SZ08061] Intensive Course Portuguese A2.1</b>   Blockkurs Portugiesisch A2.1                                                                                                                                                                         | 1056        |
| <b>[BV620003] Interaction between Sustainability and Building Culture</b>   Wechselwirkungen zwischen Nachhaltigkeit und Baukultur                                                                                                                       | 239 - 241   |
| <b>[CLA20424] Intercultural Encounters</b>   Interkulturelle Begegnungen                                                                                                                                                                                 | 929 - 930   |
| <b>[CLA11317] Interdisciplinary Lecture Series Environment: Politics and Society</b>   Ringvorlesung Umwelt: Politik und Gesellschaft                                                                                                                    | 925 - 926   |
| <b>[EI7467] Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country</b>   Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country [ProRESDC] | 446 - 448   |
| <b>[EI7467] Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country</b>   Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country [ProRESDC] | 1264 - 1266 |
| <b>[ED120049] Interdisciplinary Summerschool Urban Design</b>   Interdisziplinäre Summerschool Städtebau                                                                                                                                                 | 244 - 245   |
| <b>[BV170009] International Water Rights and Politics</b>   Internationales Wasserrecht [GRAMBOW]                                                                                                                                                        | 105 - 106   |
| <b>[BV170009] International Water Rights and Politics</b>   Internationales Wasserrecht [GRAMBOW]                                                                                                                                                        | 792 - 793   |
| <b>[BV170009] International Water Rights and Politics</b>   Internationales Wasserrecht [GRAMBOW]                                                                                                                                                        | 1334 - 1335 |
| <b>[ED110046] Internet of Things in the Built Environment</b>   Internet der Dinge in der gebauten Umwelt                                                                                                                                                | 1258 - 1260 |
| <b>[BV000122] Introduction into Technical Acoustics</b>   Einführung in die Technische Akustik                                                                                                                                                           | 1213 - 1215 |
| <b>[WI001122] Introduction to Business Law (MiM)</b>   Introduction to Business Law (MiM) [BusLawMiM]                                                                                                                                                    | 1110 - 1111 |
| <b>[BGU45037] Introduction to Earth System Science</b>   Einführung in die Erdsystemforschung                                                                                                                                                            | 1187 - 1189 |
| <b>[ED130007] Introduction to Machine Learning and Applications in Hydraulic and Hydro-Morphology</b>   Einführung in Machine Learning und Anwendungen in der Hydraulik und Hydromorphologie [MLHM]                                                      | 144 - 146   |
| <b>[MW1535] Introduction to Patent, Trademark and Design Law for Engineers</b>   Patent-, Marken- und Musterrecht für Ingenieure: Eine Einführung                                                                                                        | 971 - 972   |
| <b>[BGU48029] Introduction to Photogrammetry and Remote Sensing</b>   Einführung in die Photogrammetrie und Fernerkundung [PRG]                                                                                                                          | 619 - 620   |
| <b>[BV480016] Introduction to Photogrammetry, Remote Sensing and Image Processing</b>   Einführung in die Photogrammetrie, Fernerkundung und Bildverarbeitung [PRC+IPC]                                                                                  | 1248 - 1250 |
| <b>[WZ2733] Introduction to Soil Science</b>   Introduction to Soil Science                                                                                                                                                                              | 1156 - 1157 |
| <b>[MW2149] Introduction to Wind Energy</b>   Introduction to Wind Energy                                                                                                                                                                                | 973 - 975   |

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| <b>[POL40100] Introductory Lecture: Politics and Technology</b>   Ringvorlesung: Politics & Technology        | 982 - 983   |
| <b>[WI001138] Investment and Financial Management (MiM)</b>   Investment and Financial Management (MiM) [IaF] | 1121 - 1122 |
| <b>[SZ0606] Italian A2.1</b>   Italienisch A2.1                                                               | 1043 - 1044 |
| <b>[SZ0607] Italian A2.1 + A2.2 - Intensive</b>   Italienisch A2.1 + A2.2 - Intensiv                          | 1045 - 1046 |
| <b>[SZ0608] Italian A2.2</b>   Italienisch A2.2                                                               | 1047 - 1048 |
| <b>[SZ0609] Italian B1.1</b>   Italienisch B1.1                                                               | 1049 - 1050 |

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| <b>[SZ0719] Japanese A2.1 + A2.2</b>   Japanisch A2.1 + A2.2 | 1051 - 1052 |
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| <b>[ED0152] Knowledge and Cognition (advanced topics)</b>   Erkenntnis und Kognition (vertieft) | 509 - 510 |
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| <b>[BGU46033] Laboratory and Field Exercises at the Obernach Lab</b>   Modelltechnische und flussbauliche Übungen an der Versuchsanstalt Obernach [VAO_2016] | 124 - 125 |
| <b>[BGU46033] Laboratory and Field Exercises at the Obernach Lab</b>   Modelltechnische und flussbauliche Übungen an der Versuchsanstalt Obernach [VAO_2016] | 198 - 199 |
| <b>[BGU46033] Laboratory and Field Exercises at the Obernach Lab</b>   Modelltechnische und flussbauliche Übungen an der Versuchsanstalt Obernach [VAO_2016] | 598 - 599 |
| <b>[BGU67001] Landslides</b>   Hangbewegungen                                                                                                                | 267 - 269 |
| <b>[BGU67001] Landslides</b>   Hangbewegungen                                                                                                                | 310 - 312 |
| <b>[BGU67001] Landslides</b>   Hangbewegungen                                                                                                                | 713 - 715 |
| <b>[BV530014] Landslide Mapping Course</b>   Hangbewegungskartierung                                                                                         | 873 - 876 |
| <b>[BV400009] Land Management and Land Policy</b>   Bodenordnung und Bodenpolitik                                                                            | 353 - 355 |
| <b>[BV400009] Land Management and Land Policy</b>   Bodenordnung und Bodenpolitik                                                                            | 830 - 832 |



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| <b>[BGU40063] Land Management International - Theory and Practice  </b><br>Landmanagement International - Theorie und Praxis                  | 425 - 427   |
| <b>[BV520008] Land Use and Transportation Modelling  </b> Modellierung von<br>Siedlungsstruktur und Verkehr                                   | 356 - 358   |
| <b>[BV520007] Land Use and Transport - Interactions and Strategies  </b><br>Siedlungsstruktur und Verkehr - Wechselwirkungen und Strategien   | 328 - 330   |
| <b>[CLA11108] Leadership  </b> Führung übernehmen                                                                                             | 919 - 920   |
| <b>[CLA31900] Lecture Series Environment - TUM  </b> Vortragsreihe Umwelt - TUM                                                               | 947 - 948   |
| <b>[WI001255] Lecture Series Renewable Energy Systems in the Global South  </b><br>Ringvorlesung Erneuerbare Energiesysteme im Globalen Süden | 455 - 457   |
| <b>[WI001255] Lecture Series Renewable Energy Systems in the Global South  </b><br>Ringvorlesung Erneuerbare Energiesysteme im Globalen Süden | 1276 - 1278 |
| <b>[BV360009] Life-cycle Assessment  </b> Ökobilanzierung                                                                                     | 236 - 238   |
| <b>[BV360009] Life-cycle Assessment  </b> Ökobilanzierung                                                                                     | 1223 - 1225 |
| <b>[WZ2469] Limnology of Running Waters  </b> Limnologie der Fließgewässer                                                                    | 492 - 493   |

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| <b>[WI001129] Marketing and Innovation Management (MiM)  </b> Marketing and<br>Innovation Management (MiM)                                                                                                                               | 1115 - 1117 |
| <b>Master's Thesis  </b> Master Thesis                                                                                                                                                                                                   | 1357        |
| <b>[BV00MTUI] Master's Thesis  </b> Master's Thesis                                                                                                                                                                                      | 1357 - 1358 |
| <b>[WZ4206] Material Flow Management and Applications  </b> Material Flow<br>Management and Applications                                                                                                                                 | 479 - 480   |
| <b>[BGU54027] Mathematical Methods for Uncertainty Quantification in<br/>Hydrology  </b> Mathematische Methoden zur Unsicherheitsquantifizierung in der<br>Hydrologie [Mathematical methods for uncertainty quantification in hydrology] | 94 - 96     |
| <b>[BGU46028] Mathematical Modeling of Hydrodynamics and Water Quality<br/>in Coastal Regions  </b> Mathematische Modellierung der Hydrodynamik und<br>Wasserqualität in Küstengebieten [COASTAL]                                        | 591 - 592   |
| <b>[BGU36008] Methods of Measurement  </b> Messtechnik Seminar                                                                                                                                                                           | 538 - 539   |
| <b>[BV380004] Microbiology of Groundwater Ecosystems  </b> Mikrobiologie von<br>Grundwasserökosystemen                                                                                                                                   | 58 - 61     |
| <b>[BV380004] Microbiology of Groundwater Ecosystems  </b> Mikrobiologie von<br>Grundwasserökosystemen                                                                                                                                   | 824 - 827   |
| <b>[BV380004] Microbiology of Groundwater Ecosystems  </b> Mikrobiologie von<br>Grundwasserökosystemen                                                                                                                                   | 1338 - 1341 |
| <b>[ED150004] Mixed Methods Procedures for Mobility Research  </b> Mixed<br>Methods Procedures for Mobility Research [MixMethods]                                                                                                        | 365 - 367   |
| <b>[BGU41019] Modeling and Simulation of Turbulent Flows  </b> Modellierung und<br>Simulation turbulenter Strömungen                                                                                                                     | 190 - 192   |

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| <b>[BGU46042] Modeling of Habitat for Fish and Invertebrates in Rivers  </b><br>Lebensraummodellierung für Fische und Wirbellose in Flüssen [HABSIM]              | 616 - 618   |
| <b>[MW2152] Modeling, Control and Design of Wind Energy Systems  </b> Modeling,<br>Control and Design of Wind Energy Systems                                      | 976 - 978   |
| <b>[BGU43026] Modelling and Simulation in Structural Mechanics  </b> Modellierung<br>und Simulation in der Strukturdynamik                                        | 1182 - 1183 |
| <b>[BV320006] Modelling in structural analysis  </b> Modellbildung in der Baustatik<br>[MB]                                                                       | 809 - 810   |
| <b>[BGU52022] Modelling of Environmental Effects in Transportation  </b><br>Modellieren von Umweltwirkungen im Verkehr [MoDEET]                                   | 325 - 327   |
| <b>[BV580008] Modelling of Environmental Effects in Transportation  </b><br>Modellieren von Umweltwirkungen im Verkehr [MoDEET]                                   | 889 - 891   |
| <b>[BV180004] Modelling of Water Quality in Aquatic Systems  </b> Modellierung der<br>Wassergüte in aquatischen Systemen                                          | 54 - 55     |
| <b>[BV180004] Modelling of Water Quality in Aquatic Systems  </b> Modellierung der<br>Wassergüte in aquatischen Systemen                                          | 315 - 316   |
| <b>[BV180004] Modelling of Water Quality in Aquatic Systems  </b> Modellierung der<br>Wassergüte in aquatischen Systemen                                          | 796 - 797   |
| <b>[ED150005] Modelling Tools and Practice Insight for Traffic Engineering  </b><br>Modellwerkzeuge und Einblick in die Praxis des Verkehrsingenieurwesens [MTPI] | 400 - 402   |
| <b>[MCTS0036] Moderation (RESET)  </b> Moderation (RESET)                                                                                                         | 518 - 519   |
| <b>Module List  </b> Modulkatalog                                                                                                                                 | 29          |
| <b>[BGU70002] Multimodal and Intermodal Freight Transport  </b> Multimodaler und<br>intermodaler Güterverkehr [Multimodal and intermodal freight transport]       | 346 - 347   |
| <b>[BGU70002] Multimodal and Intermodal Freight Transport  </b> Multimodaler und<br>intermodaler Güterverkehr [Multimodal and intermodal freight transport]       | 734 - 735   |

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| <b>[WZ1821] Natural Resources - Traits, Management and Theory of Sustainability  </b> Natural Resources - Traits, Management and Theory of Sustainability            | 1149 - 1150 |
| <b>[BV040005] Nature-oriented Care  </b> Naturnahe Bauweisen                                                                                                         | 103 - 104   |
| <b>[BV040005] Nature-oriented Care  </b> Naturnahe Bauweisen                                                                                                         | 767 - 768   |
| <b>[SZ1702] Norwegian A2  </b> Norwegisch A2                                                                                                                         | 1095 - 1096 |
| <b>[SZ1703] Norwegian B1  </b> Norwegisch B1                                                                                                                         | 1097 - 1098 |
| <b>[BGU54019] Numerical Modeling of Water Demand and Supply in Arid Regions  </b> Numerische Modellierung von Wasserbedarf und -Versorgung in ariden Gebieten [OWHM] | 86 - 87     |

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| <b>[BGU54019] Numerical Modeling of Water Demand and Supply in Arid Regions</b>   Numerische Modellierung von Wasserbedarf und -Versorgung in ariden Gebieten [OWHM] | 154 - 155 |
| <b>[BGU54019] Numerical Modeling of Water Demand and Supply in Arid Regions</b>   Numerische Modellierung von Wasserbedarf und -Versorgung in ariden Gebieten [OWHM] | 652 - 653 |
| <b>[BV410009] Numerical River Hydraulics</b>   Numerische Gerinnehydraulik [NRH]                                                                                     | 215 - 216 |
| <b>[BV410009] Numerical River Hydraulics</b>   Numerische Gerinnehydraulik [NRH]                                                                                     | 837 - 838 |
| <b>[BV490053] Numeric Analysis 1 - Fundamentals</b>   Numerische Methoden 1 - Grundlagen                                                                             | 319 - 321 |
| <b>[BV490054] Numeric Analysis 2 - Numerical Modeling</b>   Numerische Methoden 2 - Codes                                                                            | 322 - 324 |

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| <b>[BGU68010] Object-Oriented Programming for Transport Engineers</b>   Objektorientiertes Programmieren für Verkehrsingenieure [Object-Oriented Programming for Transport Engineers] | 731 - 733   |
| <b>[BGU46040] Ocean and Wind Energy</b>   Meeres- und Windenergie [OWE]                                                                                                               | 610 - 612   |
| <b>[BGU46040] Ocean and Wind Energy</b>   Meeres- und Windenergie [OWE]                                                                                                               | 1320 - 1322 |
| <b>[BGU46040] Ocean and Wind Energy</b>   Meeres- und Windenergie [OWE]                                                                                                               | 1323 - 1325 |
| <b>[BGU70003] Optimisation for Transportation Systems</b>   Optimierung für Verkehrssysteme [Optimisation for Transportation Systems]                                                 | 736 - 737   |
| <b>[BGU37016] Optimization of building materials for practical applications</b>   Anwendungsgerechte Optimierung mineralischer Baustoffe                                              | 542 - 544   |
| <b>[CH0141] Organic Environmental Chemistry</b>   Organische Umweltchemie                                                                                                             | 909 - 910   |

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| <b>[BV440004] Parallel Computing</b>   Paralleles Rechnen                                             | 848 - 850   |
| <b>[BGU900035] Partner University DTU - Project Studies</b>   Partneruniversität DTU - Projektstudium | 1355 - 1356 |
| <b>[BGU900011] Partner University - Elective Module</b>   Partneruniversität - Wahlmodul              | 490 - 491   |
| <b>[BGU900013] Partner University - Elective Module</b>   Partneruniversität - Wahlmodul              | 1170 - 1171 |
| <b>[BGU900011] Partner University - Elective Module</b>   Partneruniversität - Wahlmodul              | 1283 - 1284 |

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| <b>[BGU900011] Partner University - Elective Module</b>   Partneruniversität - Wahlmodul                                                                                                | 1285 - 1286 |
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| <b>[BGU54026] Urban Flood Modelling</b>   Modellierung städtischer Überschwemmungen [UFM]                                                                                                                         | 293 - 294   |
| <b>[BGU54026] Urban Flood Modelling</b>   Modellierung städtischer Überschwemmungen [UFM]                                                                                                                         | 660 - 661   |
| <b>[BGU56056] Urban Ropeways</b>   Urbane Seilbahnen [URW]                                                                                                                                                        | 379 - 380   |
| <b>[BGU70008] Urban Transportation Systems: Operations Research and Emerging Mobility Technologies</b>   Urbane Verkehrssysteme: Betriebsforschung und neue Mobilitätstechnologien [Urban Transportation Systems] | 392 - 394   |
| <b>[BGU70008] Urban Transportation Systems: Operations Research and Emerging Mobility Technologies</b>   Urbane Verkehrssysteme: Betriebsforschung und neue Mobilitätstechnologien [Urban Transportation Systems] | 746 - 748   |
| <b>[BV210013] Urban und Regional Planning</b>   Stadt- und Regionalplanung                                                                                                                                        | 806 - 808   |
| <b>[BGU38038] Urban Water-Energy-Food Nexus</b>   Urban Water-Energy-Food Nexus [WEF Nexus]                                                                                                                       | 403 - 405   |

## V

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| <b>[WZ1561] Value Chain Economics</b>   Value Chain Economics                                                  | 496 - 499   |
| <b>[BGU43025] Vibroacoustics</b>   Vibroakustik                                                                | 1179 - 1181 |
| <b>[BGU52015] Visualization of Spatial Data in Transportation</b>   Visualisierung von Raum- und Verkehrsdaten | 627 - 629   |

## W

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| <b>[BGU38011] Wastewater Conveyance Systems and Stormwater Management</b><br>  Bewirtschaftung von Kanalnetzen und Regenwassermanagement                                                 | 73 - 74     |
| <b>[BGU38011] Wastewater Conveyance Systems and Stormwater Management</b><br>  Bewirtschaftung von Kanalnetzen und Regenwassermanagement                                                 | 550 - 551   |
| <b>[BGU38014] Water and Wastewater Treatment Engineering</b>  <br>Wasserversorgung, Wasseraufbereitung und Abwasserbehandlung                                                            | 29 - 31     |
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| <b>[BGU54015] Water Management at the Catchment Scale (Field trip to the Adige River Basin)</b>   Wassermanagement auf Einzugsgebietsebene (Exkursion in das Etsch Einzugsgebiet) [WMCS] | 84 - 85     |
| <b>[BGU54015] Water Management at the Catchment Scale (Field trip to the Adige River Basin)</b>   Wassermanagement auf Einzugsgebietsebene (Exkursion in das Etsch Einzugsgebiet) [WMCS] | 647 - 648   |
| <b>[BGU46036] Water Resources and Hydropower</b>   Wasserwirtschaft und Wasserkraft [WRHP]                                                                                               | 75 - 77     |
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| <b>[BGU38028] Water Resource Recovery Process Simulation and Design  </b><br>Prozesssimulation und Design von Kläranlagen    | 566 - 568   |
| <b>[BGU38028] Water Resource Recovery Process Simulation and Design  </b><br>Prozesssimulation und Design von Kläranlagen    | 1299 - 1301 |
| <b>[CLA10450] When Engineers Become Managers  </b> Wenn aus Ingenieuren<br>Manager werden                                    | 915 - 916   |
| <b>[WZ4198] Wildlife Management and Wildlife-Human Interactions  </b> Wildlife<br>Management and Wildlife-Human Interactions | 500 - 501   |
| <b>[WZ2735] World Soil Resources  </b> World Soil Resources                                                                  | 1160 - 1161 |