TUHH
Hamburg
University of
Technology

# Module Manual

Master of Science (M.Sc.)

# Environmental Engineering
# Dual study program

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# Program description

## Content

Environmental engineering has never been more relevant than it is today. In the past 20 years, the field has moved from purely focusing on the technical and logistical side of waste disposal to encompass material recovery and circular economy. Innovative materials, integrated material and process flow analysis, as well as the involvement of energy sector issues, have brought environmental technology - once a niche sector perceived to be partly driven by ideology - into mainstream areas of the international economy. Germany is a global market leader in many areas of environmental engineering expertise. This status requires ongoing success at different levels: innovative and integrated technology, favourable legal and economic standards and, not least, high-quality German university education in environmental sciences.

With this in mind, the International Master Program in Environmental Engineering at the Hamburg University of Technology (TUHH) focuses on current developments in environmental technology, while also providing a solid grounding in the subject's scientific and economic foundations. Students can specialise in one of three areas: (i) Water, (ii) Waste & Energy or (iii) Biotechnology. Interdisciplinary considerations are essential to all subject areas. How can environmental pollution be reduced and valuable resources recovered at the same time? How does one measure the sustainability of a product or service? Which innovative technologies assure minimum energy use in production processes? Which environmental law constraints favour sustainable development? All these questions are relevant in the Environmental Engineering program.

Graduates of the Environmental Engineering program have a detailed understanding of key areas of environmental sciences. At the start of the Master's program, all students take compulsory courses in environmental management, waste and wastewater treatment, fluid dynamics and hydrology, and environmental analytics. In the second semester, students can choose from a number of potential core areas. These include courses in geochemical engineering, technical microbiology and water and wastewater technology. From the third semester, students develop a specialisation in one of the areas mentioned above (Water, Waste and Energy, or Biotechnology). In addition to course-specific modules, students also take non-technical classes in subjects such as business economics or foreign languages.

In addition to the foundational curriculum taught at TUHH, seminars on developing personal skills are integrated into the dual study programme, in the context of transfer between theory and practice. These seminars correspond to the modern professional requirements expected of an engineer, as well as promoting the link between the two places of learning.

The intensive dual courses at TUHH integrating practical experience consist of an academic-oriented and a practice-oriented element, which are completed at two places of learning. The academic-oriented element comprises study at TUHH. The practice-oriented element is coordinated with the study programme in terms of content and time, and consists of practical modules and phases spent in an affiliate company during periods when there are no lectures.

## Career prospects

Graduates of the International Master Program in Environmental Engineering are sought after in a broad range of different fields and have excellent prospects in terms of career development. Graduates may work, for example, for environmental authorities, water and wastewater companies, energy and waste management companies, engineering firms or in the biotechnology industry. Owing to the breadth and diversity of the course, Environmental Engineering graduates are able to quickly familiarise themselves with new information, which is highly beneficial when working in interdisciplinary teams, as will often be the case. Worldwide, the environmental technology sector is growing strongly. Inadequate environmental management can have a significantly negative impact on the economic development of a region or country. In light of the above, Environmental Engineering graduates are international in their outlook and employed around the world. In addition to preparing students for demanding careers in industry, the Master's in Environmental Engineering also equips students with the necessary academic skills for pursuing their possible further specialisation at PhD level.

In addition, students acquire basic professional and personal skills as part of the dual study programme that enable them to enter professional practice at an early stage and to go on to further study. Students also gain practical work experience through the integrated practical modules. Graduates of the dual course have broad foundational knowledge, fundamental skills for academic work and relevant personal competences.

## Learning target

Environmental Engineering graduates should have certain core skills and knowledge. These are listed below in the following categories: knowledge, skills, social skills and independence.

**Knowledge:**

1. Graduates are able to describe the fundamentals of environmental management and outline environmental standards, environmental economic instruments, the content of ISO 14001 and environmental performance evaluation.
2. They are able to explain the procedural fundamentals of important water and wastewater treatment techniques, biotechnological processes, biological waste treatment (aerobic and anaerobic) and relevant environmental chemicals and their analytical determination, particularly in water and wastewater analysis.
3. They can discuss hydrological and fluid mechanical models and the technical boundary conditions for sustainable water protection.
4. They are able to define the key principles of circular economy (water/waste) and outline the fundamentals of business economics.
5. Depending on the specialisation they choose, graduates can demonstrate their broader understanding in the areas of water, waste and energy or biotechnology.

**Skills:**

1. Graduates are able to complete practical laboratory work in the area of municipal water engineering taking into consideration the procedure selection for water and wastewater treatment processes.
2. They are able to conduct specialist scientific research and geographical data processing and apply hydrological models.
3. They are able to argue and write scientifically.
4. Graduates are able to produce incisive individual presentations and coordinated team presentations, as practised in classes involving problem-based learning (PBL).
5. They are able to apply fundamental business economics methods.
6. Depending on their chosen specialisation, they have further skills in the areas of water, energy and waste, or biotechnology. For example, they are able to design membrane separation processes, conduct modelling in water technology, select technical and regional planning solutions for tasks in a biorefinery or analyse and evaluate integrated waste management solutions.

**Social skills:**

1. The degree program Environmental Engineering attracts students from all over the world. From the beginning of the course, students work in diverse teams, in which they are able to use their different skill sets and values productively when working on technical problems.
2. On completion of their studies, students are able to develop technical proposals, comprehensively review results and, where relevant, confirm them through peer discussion.

3. They can present technical solutions as a team.
4. They can also give constructive feedback to fellow students and integrate feedback on their own performance appropriately into their own work.

**Autonomy:**

1. Graduates of the Environmental Engineering program are able to conduct independent research using scientific literature; read test reports; gain knowledge from these reports and transfer it to the project at hand.
2. In consultation with teaching staff, they are able to evaluate their own learning in concrete terms and define subsequent steps for ongoing progress.
3. They can independently define research and development tasks for theoretical and experimental investigation of environmental issues and plan and carry out projects in this regard.

By continually switching places of learnings throughout the dual study programme, it is possible for theory and practice to be interlinked. Students reflect theoretically on their individual professional practical experience, and apply the results of their reflection to new forms of practice. They also test theoretical elements of the course in a practical setting, and use their findings as a stimulus for theoretical debate.

## Program structure

The Master's program in Environmental Engineering is composed primarily of modules with six credit points (CPs). One CP equates to a student workload of 30 hours (classroom contact hours and study undertaken at home, including examination preparation). Master's students must complete 150 CPs in four semesters over a two-year period.

The modules are divided into: (i) **core qualification,** (ii) **specialisation** and (iii) **thesis**. For the **core qualification**, all students initially attend compulsory courses amounting to 42 CPs. These are primarily completed in the first and second semesters. Based on their individual interests, students take a further 18 CPs from a possible 30 CPs of elective courses. These modules are primarily completed in the second and third semesters. It is obligatory for students to take one business economics module and a module with non-technical courses (foreign language, art or cultural courses). **Specialisation** encompasses 12 CPs of obligatory courses (project work) and 18 CPs elective courses, to be selected from the study options in the specialisations Water, Waste and Energy, or Biotechnology. These modules are primarily completed in the third semester. In the fourth semester, students complete their **thesis** (30 CPs). This is preferably completed in the student's specialisation, though this is not obligatory. The third or fourth semester is most suited to students wishing to spend time abroad or on an industry placement as project and thesis work can be completed independent of lecture periods and in direct agreement with the supervising Professor.

The structural model of the dual study programme follows a module-differentiating approach. Given the practice-oriented element, the curriculum of the dual study programme is different compared to a standard Bachelor's course. Five practical modules are completed at the dual students' partner company as part of corresponding practical terms during lecture-free periods.

# Core Qualification

## Module M0523: Business & Management

| | |
|---|---|
| **Module Responsible** | Prof. Matthias Meyer |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | None |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students are able to find their way around selected special areas of management within the scope of business management.<br>• Students are able to explain basic theories, categories, and models in selected special areas of business management.<br>• Students are able to interrelate technical and management knowledge. |
| *Skills* | • Students are able to apply basic methods in selected areas of business management.<br>• Students are able to explain and give reasons for decision proposals on practical issues in areas of business management. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems |
| *Autonomy* | • Students are capable of acquiring necessary knowledge independently by means of research and preparation of material. |
| **Workload in Hours** | Depends on choice of courses |
| **Credit points** | 6 |

**Courses**

**Information regarding lectures and courses can be found in the corresponding module handbook published separately.**

## Module M0619: Waste Treatment Technologies

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Waste and Environmental Chemistry (L0328) | Practical Course | 2 | 2 |
| Biological Waste Treatment (L0318) | Project-/problem-based Learning | 3 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Kerstin Kuchta |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | chemical and biological basics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The module aims possess knowledge concerning the planning of biological waste treatment plants. Students are able to explain the design and layout of anaerobic and aerobic waste treatment plants in detail, describe different techniques for waste gas treatment plants for biological waste treatment plants and explain different methods for waste analytics. |
| *Skills* | The students are able to discuss the compilation of design and layout of plants. They can critically evaluate techniques and quality control measurements. The students can recherché and evaluate literature and date connected to the tasks given in der module and plan additional tests. They are capable of reflecting and evaluating findings in the group. |
| **Personal Competence** | |
| *Social Competence* | Students can participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development in front of colleagues. Furthermore, they can give and accept professional constructive criticism. |
| *Autonomy* | Students can independently tap knowledge from literature, business or test reports and transform it to the course projects. They are capable, in consultation with supervisors as well as in the interim presentation, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**: Yes / None / Subject theoretical and practical work |
| **Examination** | Presentation |
| **Examination duration and scale** | Elaboration and Presentation (15-25 minutes in groups) |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Environmental Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory |

| Course L0328: Waste and Environmental Chemistry | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | The participants are divided into groups. Each group prepares a transcript on the experiment performed, which is then used as basis for discussing the results and to evaluate the performance of the group and the individual student.<br><br>In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation.<br><br>Experiments ar e.g.<br><br>Screening and particle size determination<br><br>Fos/Tac<br><br>AAS<br><br>Chalorific value |
| **Literature** | Scripte |

| Course L0318: Biological Waste Treatment | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | 1. Introduction<br>2. biological basics<br>3. determination process specific material characterization<br>4. aerobic degradation ( Composting, stabilization)<br>5. anaerobic degradation (Biogas production, fermentation)<br>6. Technical layout and process design<br>7. Flue gas treatment<br>8. Plant design practical phase |
| **Literature** | |

## Module M1311: Sustainable Water Management and Microbiology of Water Systems

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Microbiology of water systems (L1782) | Lecture | 2 | 3 |
| Sustainable Water Management (L0406) | Project-/problem-based Learning | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Mathias Ernst |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in water chemistry, Knowledge of main water treatment processes |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will be able to explain the relevance of local and national water cycles on basis of water recycling targets. They will be able to separate into conventional and advanced treatment processes for both, drinking and wastewater treatment. Students are capable to name basic differences between water chemical parameters in drinking and wastewater analysis and define their significance for a sustainable water management.<br><br>Students will be able to differentiate between natural and hygienically relevant bacteria in drinking water and will know modern microbiological methods for routine and scientific analyses of drinking water. They are familiar with the diverse microbiological processes in drinking water treatment and supply. The students know the legal regulations of the microbiological drinking water quality. |
| *Skills* | On basis of water use targets students will be able to prepare combinations of naturally based as well as technical water treatment processes. They will be able to calculate key parameters of treatment pathways for a water recycling study. Students will be able to deputise their conceptual design study by argumentation.<br><br>Students will be capable to assess risks for the hygienic state of drinking water. Based on knowledge of methods they are able to evaluate results of routine analyses and research. Based on knowledge of processes, students will be able to suggest solutions to problems in drinking water supply. |
| **Personal Competence** | |
| *Social Competence* | Students will be able to work in diverse teams on problems in the field of sustainable water management. They will be able to coordinate complex tasks within their group and hand out duties accordingly. |
| *Autonomy* | Students will be in a position to work out presentations in the field of sustainable water management. They will be capable of finding creative solutions for water recycling concepts.<br><br>Students will know how to use their technical knowledge for solving problems. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: Yes; Bonus: 20 %; Form: Presentation; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min exam |
| **Assignment for the Following Curricula** | Environmental Engineering: Core Qualification: Compulsory |

| Course L1782: Microbiology of water systems | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Johannes Gescher, Prof. Mathias Ernst |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Natural and hygienically relevant microorganisms in drinking water<br>• Quantification of bacteria in drinking water<br>• Identification of bacteria<br>• Bacterial population analyses<br>• Growth of bacteria and VBNC-state<br>• Activity of bacteria in the environment<br>• Biofilms in drinking water systems<br>• Disinfection of drinking water and drinking water systems<br>• Microbiological processes in drinking water treatment<br>• Technical realization for optimized use of microbiological processes for drinking water production<br>• Impact factors on microbiological drinking water quality during distribution and compliance with legal requirements on hygiene at the consumer's tap |
| **Literature** | • Allgemeine Mikrobiologie. 2007. Fuchs, G. (Hrsg.), 8. Aufl., Thieme Verlag, Stuttgart.<br>• Brock Biology of Microorganisms. 2015. Madigan, M. T., Martinko, J. M., Bender, K. S., Buckley, D. H., and Stahl, D. A. (eds.), 14. edition, Pearson Education Ltd, Harlow, UK.<br>• Microbial growth in drinking- water supplies: Problems, causes control and research needs. 2014. Van der Kooij, D. and Van der Wielen, P. W. J. J. (eds.) IWA Publishing, London. |

| Course L0406: Sustainable Water Management | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Mathias Ernst |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | The course provides knowledge on the sustainable treatment and management of the resource water. Used water is an alternative resource and can be recycled in any field of the urban water cycle after adequate treatment. The resulting water quality is the decisive issue. In the course the central quality parameters of drinking- as well as wastewater assessment will be presented and discussed. Moreover the legal frame for water reuse in the EU and examples from all over the world will be communicated. The students receive the task to develop a conceptual design study of an indirect potable reuse facility in given boundary conditions. To fulfill this task, the students will work in small groups representing a consulting firm. Later in the course the firms will present their concepts. In preparation to the team presentation further knowledge on alternative water resources and sustainable management will be provided. International case studies will be presented and discussed. Next to the communication of technical details, planning tools for the implementation of alternative water management will be given also Option for an effective public perception program of later water users. |
| **Literature** | • Milestones in Water Reuse, V. Lazarova, T. Asano, A. Bahri, J. Anderson, IWA Publishing 2013<br>• Current UN World Water Development Reports<br>• Water Security for Better Lives, OECD Studie 2013<br>• PPT's provided during the course |

## Module M1313: Fluid Mechanics, Hydraulics and Geo-Information-Systems in Water Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Geo-Information-Systems in Water Management and Hydraulic Engineering (L0963) | Project-/problem-based Learning | 2 | 2 |
| Fluid Mechanics and Hydraulics (L1246) | Lecture | 2 | 2 |
| Fluid Mechanics and Hydraulics (L1656) | Recitation Section (small) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics (calculus) and physics; Knowledge of statics and thermodynmaik would be beneficial. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After finishing the module the students will lern the properties of fluid, hydrostatics, Fluid kinematics, conservation equations (mass, energy and momentum), flow in pipes, boundary layer theory , viscous flow (skin friction and drag forces), flow in pipes, hydraulics of open channel, flow in compound and natural channels, energy head losses. |
| *Skills* | The students will be capable to calculate and analyse the forces in the fluids as well as flow in pipes and channels. |
| **Personal Competence** | |
| *Social Competence* | The students learn to deploy their knowledge in applied problems such as calculation of water level and the rate of water rise in flood events. Furthermore, they will be able to work in team with engineers of other disciplines, for instance by designing of gates. |
| *Autonomy* | The students will be able to independently extend their knowledge and applyit to new problems. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 150 minutes including definition and descriptions as well as calculations |
| **Assignment for the Following Curricula** | Environmental Engineering: Core Qualification: Compulsory |

### Course L0963: Geo-Information-Systems in Water Management and Hydraulic Engineering

| | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | Theoretical basics of Geo-Information-Systems<br>• Data models, geographical coordinates, geo-referencing, map-views<br>• Data mining and – analyses of geo-data<br>• Analysis techniques |
| **Literature** | None |

### Course L1246: Fluid Mechanics and Hydraulics

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Mohammad Hassan Nasermoaddeli |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Properties of fluid, hydrostatics, Fluid kinematics, conservation equations (mass, energy and momentum), flow in pipes, boundary layer theory of laminar and turbulent flow, viscous flow (skin friction and drag forces), open channel hydraulics, flow in compound and natural channels, local energy head losses |
| **Literature** | R.L. Street, G.Z. Watters, J.K. Vennard: Elementary Fluid Mechanics, 7th edition, 1996<br><br>Chow, V.T., Open Channel hydraulics, Ven Te Chow, 1988 |

| Course L1656: Fluid Mechanics and Hydraulics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Dr. Mohammad Hassan Nasermoaddeli |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1312: Environmental Analysis and Water Technology Practice

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical Course in Water and Wastewater Technology I (L0503) | Practical Course | 3 | 3 |
| Environmental Analysis (L0354) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Dr. Dorothea Rechtenbach |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in chemistry and physics (knowledge required at school) |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students know basic analytical procedures for evaluating the quality of different environmental compartments. |
| *Skills* | The students are able to understand and to practically apply methodologies for environmental analysis as well as descriptions of experiments and experimental setups in wasterwater analysis. |
| **Personal Competence** | |
| *Social Competence* | The students are able to organize working processes within a team in a targeted way and based on the divison of labour. |
| *Autonomy* | The students are able to independently exploit sources and conduct experiments following written procedures without external assistance. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes written exam including written report for the practical |
| **Assignment for the Following Curricula** | Environmental Engineering: Core Qualification: Compulsory |

### Course L0503: Practical Course in Water and Wastewater Technology I

| | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Dr. Dorothea Rechtenbach |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | - Impact of pretreatment of wastewater samples on analytical results<br>- Analysis of nutrients in wastewater samples (different methods for nitrate analysis)<br>- Alkalinity<br>- TOC, COD<br>- microscopic analysis of microorganisms relevant in wastewater treatment |
| **Literature** | Skript auf StudIP |

| Course L0354: Environmental Analysis | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Dorothea Rechtenbach, Dr. Henning Mangels |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Introduction<br><br>Sampling in different environmental compartments, sample transportation, sample storage<br><br>Sample preparation<br><br>Photometry<br><br>Wastewater analysis<br><br>Introduction into chromatography<br><br>Gas chromatography<br><br>HPLC<br><br>Mass spectrometry<br><br>Optical emission spectrometry<br><br>Atom absorption spectrometry<br><br>Quality assurance in environmental analysis |
| **Literature** | Roger Reeve, Introduction to Environmental Analysis, John Wiley & Sons Ltd., 2002 (TUB: USD-728)<br><br>Pradyot Patnaik, Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes, CRC Press, Boca Raton, 2010 (TUB: USD-716)<br><br>Chunlong Zhang, Fundamentals of Environmental Sampling and Analysis, John Wiley & Sons Ltd., Hoboken, New Jersey, 2007 (TUB: USD-741)<br><br>Miroslav Radojević, Vladimir N. Bashkin, Practical Environmental Analysis<br>RSC Publ., Cambridge, 2006 (TUB: USD-720)<br><br>Werner Funk, Vera Dammann, Gerhild Donnevert, Sarah Iannelli (Translator), Eric Iannelli (Translator), Quality Assurance in Analytical Chemistry: Applications in Environmental, Food and Materials Analysis, Biotechnology, and Medical Engineering, 2nd Edition, WILEY-VCH Verlag GmbH & Co. KGaA,Weinheim, 2007 (TUB: CHF-350)<br><br>STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, 21st Edition, Andrew D. Eaton, Leonore S. Clesceri, Eugene W. Rice, and Arnold E. Greenberg, editors, 2005 (TUB:CHF-428)<br><br>K. Robards, P. R. Haddad, P. E. Jackson, Principles and Practice of<br>Modern Chromatographic Methods, Academic Press<br><br>G. Schwedt, Chromatographische Trennmethoden, Thieme Verlag<br><br>H. M. McNair, J. M. Miller, Basic Gas Chromatography, Wiley<br><br>W. Gottwald, GC für Anwender, VCH<br><br>B. A. Bidlingmeyer, Practical HPLC Methodology and Applications, Wiley<br><br>K. K. Unger, Handbuch der HPLC, GIT Verlag<br><br>G. Aced, H. J. Möckel, Liquidchromatographie, VCH<br><br>Charles B. Boss and Kenneth J. Fredeen, Concepts, Instrumentation and Techniques in Inductively Coupled Plasma Optical Emission Spectrometry<br>Perkin-Elmer Corporation 1997, On-line available at:<br>http://files.instrument.com.cn/bbs/upfile/2006291448.pdf<br><br>Atomic absorption spectrometry: theory, design and applications, ed. by S. J. Haswell 1991 (TUB: 2727-5614)<br><br>Royal Society of Chemistry, Atomic absorption spectometry (http://www.kau.edu.sa/Files/130002/Files/6785_AAs.pdf) |

| Module M1759: Linking theory and practice (dual study program, Master's degree) | |
|---|---|
| **Module Responsible** | Dr. Henning Haschke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Successful completion of practical modules as part of the dual Bachelor’s course<br>• Module "interlinking theory and practice as part of the dual Master’s course" |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students ...<br>... can describe and classify selected classic and current theories, concepts and methods<br>• related to project management and<br>• change and transformation management<br>... and apply them to specific situations, processes and plans in a personal, professional context. |
| *Skills* | Dual students ...<br>• ... anticipate typical difficulties, positive and negative effects, as well as success and failure factors in the engineering sector, evaluate them and consider promising strategies and courses of action.<br>• ... develop specialised technical and conceptual skills to solve complex tasks and problems in their professional field of activity/work. |
| **Personal Competence** | |
| *Social Competence* | Dual students ...<br>• ... can responsibly lead interdisciplinary teams within the framework of complex tasks and problems.<br>• ... engage in sector-specific and cross-sectoral discussions with experts, stakeholders and staff, representing their approaches, points of view and work results. |
| *Autonomy* | Dual students ...<br>• ... define, reflect and evaluate goals and measures for complex application-oriented projects and change processes.<br>• ... shape their professional area of responsibility independently and sustainably.<br>• ... take responsibility for their actions and for the results of their work. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Studienbegleitende und semesterübergreifende Dokumentation: Die Leistungspunkte für das Modul werden durch die Anfertigung eines digitalen Lern- und Entwicklungsberichtes (E-Portfolio) erworben. Dabei handelt es sich um eine fortlaufende Dokumentation und Reflexion der Lernerfahrungen und der Kompetenzentwicklung im Bereich der Personalen Kompetenz. |

| Course L2890: Responsible Project Management in Engineering (for Dual Study Program) | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Dr. Henning Haschke, Heiko Sieben |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | • Theories and methods of project management<br>• Innovation management<br>• Agile project management<br>• Fundamentals of classic and agile methods<br>• Hybrid use of classic and agile methods<br>• Roles, perspectives and stakeholders throughout the project<br>• Initiating and coordinating complex engineering projects<br>• Principles of moderation, team management, team leadership, conflict management<br>• Communication structures: in-house, cross-company<br>• Public information policy<br>• Promoting commitment and empowerment<br>• Sharing experience with specialists and managers from the engineering sector<br>• Documenting and reflecting on learning experiences |
| **Literature** | Seminarapparat |

| Course L2891: Responsible Change and Transformation Management in Engineering (for Dual Study Program) | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Dr. Henning Haschke, Heiko Sieben |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | • Basic concepts, opportunities and limits of organisational change<br>• Models and methods of organisational design and development<br>• Strategic orientation and change, and their short-, medium- and long-term consequences for individuals, organisations and society as a whole<br>• Roles, perspectives and stakeholders in change processes<br>• Initiating and coordinating change measures in engineering<br>• Phase models of organisational change (Lewin, Kotter, etc.)<br>• Change-oriented information policy and dealing with resistance and uncertainty<br>• Promoting commitment and empowerment<br>• Successfully handling change and transformation: personally, as an employee, as a manager (personal, professional, organisational)<br>• Company-level and globally (systemic)<br>• Sharing experience with specialists and managers from the engineering sector<br>• Documenting and reflecting on learning experiences |
| **Literature** | Seminarapparat |

## Module M1756: Practical module 1 (dual study program, Master's degree)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical term 1 (dual study program, Master's degree) (L2887) | | 0 | 10 |

| | |
|---|---|
| **Module Responsible** | Dr. Henning Haschke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Successful completion of a compatible dual B.Sc. at TU Hamburg or comparable practical work experience and competences in the area of interlinking theory and practice<br>• Course D from the module on interlinking theory and practice as part of the dual Master's course |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students ...<br>• ... combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity in engineering.<br>• ... have a critical understanding of the practical applications of their engineering subject. |
| *Skills* | Dual students ...<br>• ... apply technical theoretical knowledge to complex, interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action.<br>• ... implement the university's application recommendations with regard to their current tasks.<br>• ... develop solutions as well as procedures and approaches in their field of activity and area of responsibility. |
| **Personal Competence** | |
| *Social Competence* | Dual students ...<br>• ... work responsibly in project teams within their working area and proactively deal with problems within their team.<br>• ... represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders. |
| *Autonomy* | Dual students ...<br>• ... define goals for their own learning and working processes as engineers.<br>• ... reflect on learning and work processes in their area of responsibility.<br>• ... reflect on the relevance of subject modules specialisations and specialisation for work as an engineer, and also implement the university's application recommendations and the associated challenges to positively transfer knowledge between theory and practice. |
| **Workload in Hours** | Independent Study Time 300, Study Time in Lecture 0 |
| **Credit points** | 10 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase. |
| **Assignment for the Following Curricula** | Civil Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Computer Science: Core Qualification: Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Energy Systems: Core Qualification: Compulsory<br>Environmental Engineering: Core Qualification: Compulsory<br>Aircraft Systems Engineering: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Information and Communication Systems: Core Qualification: Compulsory<br>International Management and Engineering: Core Qualification: Compulsory<br>Logistics, Infrastructure and Mobility: Core Qualification: Compulsory<br>Aeronautics: Core Qualification: Compulsory<br>Materials Science and Engineering: Core Qualification: Compulsory<br>Materials Science: Core Qualification: Compulsory<br>Mechanical Engineering and Management: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Biomedical Engineering: Core Qualification: Compulsory<br>Microelectronics and Microsystems: Core Qualification: Compulsory<br>Product Development, Materials and Production: Core Qualification: Compulsory<br>Renewable Energies: Core Qualification: Compulsory |

| | |
|---|---|
| | Naval Architecture and Ocean Engineering: Core Qualification: Compulsory<br>Theoretical Mechanical Engineering: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Water and Environmental Engineering: Core Qualification: Compulsory |

| **Course L2887: Practical term 1 (dual study program, Master's degree)** | |
|---|---|
| **Typ** | |
| **Hrs/wk** | 0 |
| **CP** | 10 |
| **Workload in Hours** | Independent Study Time 300, Study Time in Lecture 0 |
| **Lecturer** | Dr. Henning Haschke |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | **Company onboarding process**<br>• Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work<br>• Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.)<br>• Working independently in a team and on selected projects - across departments and, if applicable, across companies<br>• Scheduling the current practical module with a clear correlation to work structures<br>• Scheduling the examination phase/subsequent study semester<br>**Operational knowledge and skills**<br>• Company-specific: Responsibility as an engineer (B.Sc.) in their own area of work, coordinating team and project work, dealing with complex contexts and unsolved problems, developing and implementing innovative solutions<br>• Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity<br>• Systemic skills<br>• Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company<br>**Sharing/reflecting on learning**<br>• Creating an e-portfolio<br>• Importance of course contents (M.Sc.) when working as an engineer<br>• Importance of development and innovation when working as an engineer |
| **Literature** | • Studierendenhandbuch<br>• Betriebliche Dokumente<br>• Hochschulseitige Handlungsempfehlungen zum Theorie-Praxis-Transfer |

## Module M1716: Subsurface Processes

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Modeling of Subsurface Processes (L2731) | Recitation Section (small) | 3 | 3 |
| Subsurface Solute Transport (L2728) | Lecture | 2 | 2 |
| Subsurface Solute Transport (L2729) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Nima Shokri |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic Mathematics, Hydrology |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Upon completion of this module, the students will understand the mechanisms controlling solute transport in soil and natural porous media and will be able to work with the equations that govern the fate and transport of solutes in porous media. Analytical, numerical and experimental tools and techniques will be used in this module. |
| *Skills* | In addition to the physical insights, the students will be exposed to analytical, experimental and numerical tools and techniques in this module. This provides them with an excellent opportunity to improve their skills on multiple fronts which will be useful in their future career. |
| **Personal Competence** | |
| *Social Competence* | Teamwork & problem solving |
| *Autonomy* | The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Report |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Civil Engineering: Specialisation Computational Engineering: Elective Compulsory<br>Environmental Engineering: Core Qualification: Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

### Course L2731: Modeling of Subsurface Processes

| | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Dr. Milad Aminzadeh |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Basic usage and background of chosen computer software to calculate flow and transport in the saturated and unsaturated zone and to analyze field data like pumping test data |
| **Literature** | |

| Course L2728: Subsurface Solute Transport | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Nima Shokri |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Basic physical properties of soil: Definition and quantification; Liquid flow in soils (Darcy's law); Solute transport in soils; Practical analysis to measure dispersion coefficient in soil under different boundary conditions; Advanced topics (e.g. Application of Artificial Intelligence to predict soil salinization) |
| **Literature** | - Environmental Soil Physics, by Daniel Hillel<br><br>- Soil Physics, Sixth Edition, by William A. Jury and Robert Horton |

| Course L2729: Subsurface Solute Transport | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Hannes Nevermann |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1757: Practical module 2 (dual study program, Master's degree)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical term 2 (dual study program, Master's degree) (L2888) | | 0 | 10 |

| | |
|---|---|
| **Module Responsible** | Dr. Henning Haschke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Successful completion of practical module 1 as part of the dual Master's course<br>• course D from the module on interlinking theory and practice as part of the dual Master's course |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students ...<br>• ... combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity in engineering.<br>• ... have a critical understanding of the practical applications of their engineering subject. |
| *Skills* | Dual students ...<br>• ... apply technical theoretical knowledge to complex, interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action.<br>• ... implement the university's application recommendations with regard to their current tasks.<br>• ... develop (new) solutions as well as procedures and approaches in their field of activity and area of responsibility - including in the case of frequently changing requirements (systemic skills). |
| **Personal Competence** | |
| *Social Competence* | Dual students ...<br>• ... work responsibly in cross-departmental and interdisciplinary project teams and proactively deal with problems within their team.<br>• ... represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders and develop these further together. |
| *Autonomy* | Dual students ...<br>• ... define goals for their own learning and working processes as engineers.<br>• ... reflect on learning and work processes in their area of responsibility.<br>• ... reflect on the relevance of subject modules specialisations and specialisation for work as an engineer, and also implement the university's application recommendations and the associated challenges to positively transfer knowledge between theory and practice. |
| **Workload in Hours** | Independent Study Time 300, Study Time in Lecture 0 |
| **Credit points** | 10 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase. |
| **Assignment for the Following Curricula** | Civil Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Computer Science: Core Qualification: Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Energy Systems: Core Qualification: Compulsory<br>Environmental Engineering: Core Qualification: Compulsory<br>Aircraft Systems Engineering: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Information and Communication Systems: Core Qualification: Compulsory<br>International Management and Engineering: Core Qualification: Compulsory<br>Logistics, Infrastructure and Mobility: Core Qualification: Compulsory<br>Aeronautics: Core Qualification: Compulsory<br>Materials Science and Engineering: Core Qualification: Compulsory<br>Materials Science: Core Qualification: Compulsory<br>Mechanical Engineering and Management: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Biomedical Engineering: Core Qualification: Compulsory<br>Microelectronics and Microsystems: Core Qualification: Compulsory<br>Product Development, Materials and Production: Core Qualification: Compulsory |

| | |
|---|---|
| | Renewable Energies: Core Qualification: Compulsory<br>Naval Architecture and Ocean Engineering: Core Qualification: Compulsory<br>Theoretical Mechanical Engineering: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Water and Environmental Engineering: Core Qualification: Compulsory |

| **Course L2888: Practical term 2 (dual study program, Master's degree)** | |
|---|---|
| **Typ** | |
| **Hrs/wk** | 0 |
| **CP** | 10 |
| **Workload in Hours** | Independent Study Time 300, Study Time in Lecture 0 |
| **Lecturer** | Dr. Henning Haschke |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | **Company onboarding process**<br>• Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work<br>• Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.)<br>• Taking personal responsibility within a team and on selected projects - across departments and, if applicable, across companies<br>• Scheduling the current practical module with a clear correlation to work structures<br>• Scheduling the examination phase/subsequent study semester<br>**Operational knowledge and skills**<br>• Company-specific: Responsibility as an engineer (B.Sc.) in their own area of work, coordinating team and project work, dealing with complex contexts and unsolved problems, developing and implementing innovative solutions<br>• Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity<br>• Systemic skills<br>• Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company<br>**Sharing/reflecting on learning**<br>• Updating their e-portfolio<br>• Importance of course contents (M.Sc.) when working as an engineer<br>• Importance of development and innovation when working as an engineer |
| **Literature** | • Studierendenhandbuch<br>• Betriebliche Dokumente<br>• Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer |

## Module M0857: Geochemical Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Contaminated Sites and Landfilling (L0906) | Lecture | 2 | 2 |
| Contaminated Sites and Landfilling (L0907) | Recitation Section (large) | 1 | 2 |
| Geochemical Engineering (L0904) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Dr. Marco Ritzkowski |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Module: General and Inorganic Chemistry,<br>Module:Organic Chemistry,<br>Biology (Basic Knowledge) |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | With the completion of this module students acquire profound knowledge of biogeochemical processes, the fate of pollutants in soil and groundwater, and techniques to deposit contaminated waste material. They are able to describe in principle the behaviour of chemicals in the environment. Students can explain and report the approach to remediate contaminated sites. |
| *Skills* | With the completion of this module students can apply the acquired theoretical knowledge to model cases of site pollution and critically assess the situation technically and conceptually. They are able to draw comparisons on different remediation strategies and techniques. Model projects can be devised and treated. |
| **Personal Competence** | |
| *Social Competence* | Students can discuss technical and scientific tasks within a seminar subject specific and interdisciplinary . |
| *Autonomy* | Students can independently exploit sources , acquire the particular knowledge of the subject and apply it to new problems. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 2 hours |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Environmental Engineering: Core Qualification: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

### Course L0906: Contaminated Sites and Landfilling

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Marco Ritzkowski, Dr. Joachim Gerth |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | The part Contaminated Sites gives an introduction into different scales of pollution and identifies key pollutants. Geochemical attenuation mechanisms and the role of organisms are highlighted affecting the fate of pollutants in leachate and groundwater. Techniques for site characterization and remediation are discussed including economical aspects.<br><br>The part Landfilling is introduced by discussing fundamental aspects and the worldwide situation of waste management. The lecture highlights transformation processes in landfill bodies, emissions of gases and leachate, and the long-term behaviour of landfill sites with measures of aftercare. |
| **Literature** | 1) **Waste Management**. Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag<br>Lehrbuchsammlung der TUB, Signatur USH-305<br><br>2) **Solid Waste Technology and Management.** Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag<br>Lesesaal 2: US - Umweltschutz, Signatur USH-332<br><br>3) **Natural attenuation of fuels and chlorinated solvents in the subsurface.** Todd H. Wiedemeier(Ed.), ISBN: 0471197491<br><br>Lesesaal 2: US - Umweltschutz, Signatur USH-844 |

| Course L0907: Contaminated Sites and Landfilling | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Dr. Marco Ritzkowski, Dr. Joachim Gerth |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0904: Geochemical Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Joachim Gerth |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | As an introduction cases are presented in which geochemical engineering was used to solve environmental problems. Environmentally important minerals are discussed and methods for their detection. It is demonstrated how solution equilibria can be modified to eliminate elevated concentrations of unwanted species in solution and how carbon dioxide concentration affects pH and the dissolution of carbonate minerals. Modifications of redox conditions, pH, and electrolyte concentration are shown to be effective tools for controlling the mobility and fate of hazardous species in the environment. |
| **Literature** | **Geochemistry, groundwater and pollution.** C. A. J. Appelo; D. Postma<br>Leiden [u.a.] Balkema 2005<br>Lehrbuchsammlung der TUB, Signatur GWC-515 |

## Module M0875: Nexus Engineering - Water, Soil, Food and Energy

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Ecological Town Design - Water, Energy, Soil and Food Nexus (L1229) | Seminar | 2 | 2 |
| Water & Wastewater Systems in a Global Context (L0939) | Lecture | 2 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf Otterpohl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of the global situation with rising poverty, soil degradation, migration to cities, lack of water resources and sanitation |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can describe the facets of the global water situation. Students can judge the enormous potential of the implementation of synergistic systems in Water, Soil, Food and Energy supply. |
| *Skills* | Students are able to design ecological settlements for different geographic and socio-economic conditions for the main climates around the world. |
| **Personal Competence** | |
| *Social Competence* | The students are able to develop a specific topic in a team and to work out milestones according to a given plan. |
| *Autonomy* | Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information can be found at the beginning of the smester in the StudIP course module handbook. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory<br>Environmental Engineering: Core Qualification: Elective Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

| Course L1229: Ecological Town Design - Water, Energy, Soil and Food Nexus | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Participants Workshop: Design of the most attractive productive Town<br>• Keynote lecture and video<br>• The limits of Urbanization / Green Cities<br>• The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities<br>• Global Ecovillage Network: Upsides and Downsides around the World<br>• Visit of an Ecovillage<br>• Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competion<br>• TUHH Rural Development Toolbox<br>• Integrated New Town Development<br>• Participants workshop: Design of New Towns: Northern, Arid and Tropical cases<br>• Outreach: Participants campaign<br>• City with the Rural: Resilience, quality of live and productive biodiversity |
| **Literature** | • Ralf Otterpohl 2013: Gründer-Gruppen als Lebensentwurf: "Synergistische Wertschöpfung in erweiterten Kleinstadt- und Dorfstrukturen", in „Regionales Zukunftsmanagement Band 7: Existenzgründung unter regionalökonomischer Perspektive, Pabst Publisher, Lengerich<br>• http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)<br>• TEDx New Town Ralf Otterpohl: http://youtu.be/_M0J2u9BrbU |

| Course L0939: Water & Wastewater Systems in a Global Context | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Keynote lecture and video<br>• Water & Soil: Water availability as a consequence of healthy soils<br>• Water and it’s utilization, Integrated Urban Water Management<br>• Water & Energy, lecture and panel discussion pro and con for a specific big dam project<br>• Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation<br>• Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches<br>• Why are there excreta in water? Public Health, Awareness Campaigns<br>• Rehearsal session, Q&A |
| **Literature** | • Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press<br>• Liu, John D.: http://eempc.org/hope-in-a-changing_climate/ (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda)<br>• http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation) |

## Module M0828: Urban Environmental Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Noise Protection (L1109) | Lecture | 2 | 2 |
| Urban Infrastructures (L0874) | Project-/problem-based Learning | 2 | 4 |

| | |
|---|---|
| **Module Responsible** | Dr. Dorothea Rechtenbach |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Knowledge on Urban planning<br>• Knowledge on measures for climate protection<br>• General knowledge of scientific writing/working |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can describe urban development corridors as well as current and future urban environmental problems. They are able to explain the causes of environmental problems (like noise).<br>Students can specify applications for various technical innovations and explain why these contribute to the improvement of urban life. They can, for example, derive and discuss measures for effective noise abatement. |
| *Skills* | Students are able to develop specific solutions for correcting existing or future environment-related problems of urban development. They can define a range of conceptual and technical solutions for environmental problems for different development paths. To solve specific urban environmental problems they can select technical innovations and integrate them into the urban context. |
| **Personal Competence** | |
| *Social Competence* | The students can work together in international groups. |
| *Autonomy* | Students are able to organize their work flow to prepare themselves for presentations and contributions to the discussions. They can acquire appropriate knowledge by making enquiries independently. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Written Report plus oral Presentation |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Environmental Engineering: Core Qualification: Elective Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Compulsory |

### Course L1109: Noise Protection

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Martin Jäschke |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | 1) Müller & Möser (2013): Handbook of Engineering Acoustics (also available in German)<br>2) WHO (1999): Guidelines for Community Noise<br>3) Environmental Noise Directive 2002/49/EG<br>4) ISO 9613-2 (1996): Acoustics, Attenuation of sound during propagation outdoors, Part 2: General method of calculation |

| Course L0874: Urban Infrastructures | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Dr. Dorothea Rechtenbach |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Problem Based Learning<br><br>Main topics are:<br><br>• Central vs. Decentral Wastewater Treatment.<br>• Compaction of Cities.<br>• Car Free Cities.<br>• Multifunctional Places in Cities.<br>• The Sustainability of Freight Transport in Cities. |
| **Literature** | Depends on chosen topic. |

## Module M0870: Management of Surface Water

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Modelling of Flow in Rivers and Estuaries (L0810) | Lecture | 3 | 4 |
| Nature-Oriented Hydraulic Engineering / Integrated Flood Protection (L0961) | Project-/problem-based Learning | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of Hydromechanics, Hydraulics, Hydrology and Hydraulic Engineering; Hydraulic Engineering I and Hydraulic Engineering II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to define in detail the basic processes that are related to the modelling of flows in hydraulic engineering. Besides, they can describe the basic aspects of numerical modelling and actual numerical models for the simulation of flows and waves. They can also depict the concepts of nature oriented hydraulic engineering. |
| *Skills* | Students are able to apply hydrodynamic-numerical models to practical hydraulic engineering tasks. Furthermore, the students are able to set up flood-risk management concepts and are able to apply basic concepts of renaturation to practical problems. |
| **Personal Competence** | |
| *Social Competence* | The students are able to deploy their gained knowledge in applied problems of the practical nature-based hydraulic engineering. Additionaly, they will be able to work in team with engineers of other disciplines. |
| *Autonomy* | The students will be able to independently extend their knowledge and apply it to new problems. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | The duration of the examination is 150 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Compulsory<br>Environmental Engineering: Core Qualification: Elective Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory<br>Water and Environmental Engineering: Specialisation Water: Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

| Course L0810: Modelling of Flow in Rivers and Estuaries | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Edgar Nehlsen, Prof. Peter Fröhle |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Introduction to numerical flow modelling<br>• Processes affecting tht flow<br>• Examples and applications of numerical models<br>• Procedure of numerical modelling<br>• Model concept<br>Basic equations of hydrodynamics<br>• Saint-Venant equations<br>• Euler Equations<br>• Navier-Stokes equations<br>• Reynolds-averaged Navier-Stokes equations<br>• Shallow water equations<br>Solving schemes<br>• Numerical discretization<br>• Solution algorithms<br>• Convergence |
| **Literature** | Vorlesungsskript<br>Literaturempfehlungen<br>Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt).<br>Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series).<br>Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019a): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 1: Geodaten in der Fließgewässermodellierung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-1).<br>Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019b): Merkblatt DWA-M 543-2 Geodaten in der Fließgewässermodellierung Teil 2: Bedarfsgerechte Datenerfassung und -aufbereitung. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-2).<br>Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. (DWA); DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische Modelle, DWA-Arbeitsgruppe WW-3.2 Mehrdimensionale numerische (2019c): Merkblatt DWA-M 543-3 Geodaten in der Fließgewässermodellierung - Teil 3: Aspekte der Strömungsmodellierung und Fallbeispiele. Februar 2019. Hennef: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (DWA-Regelwerk, 543-3).<br>Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html.<br>IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92.<br>Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology.<br>Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83).<br>van Waveren, Harold (1999-): Good modelling practice handbook. [Utrecht], Lelystad, Den Haag: STOWA; Rijkswaterstaat-RIZA; SDU, afd. SEO/RIZA [etc. distr.] (Nota, nr. 99.036).<br>Zielke, Werner (Hg.) (1999): Numerische Modelle von Flüssen, Seen und Küstengewässern. Deutscher Verband für Wasserwirtschaft und Kulturbau. Bonn: Wirtschafts- und Verl.-Ges. Gas und Wasser (Schriftenreihe des Deutschen Verbandes für Wasserwirtschaft und Kulturbau, 127). |

| Course L0961: Nature-Oriented Hydraulic Engineering / Integrated Flood Protection | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Natasa Manojlovic, Prof. Peter Fröhle |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | • Regime-Theory and application for the development of environmental guiding priciples of rivers<br>• Engineering - biological measures for the stabilization of rivers<br>• Risk management in flood protection<br>• Design techniques in technical flood protection<br>• Methods for the assessment of flood caused damages |
| **Literature** | Vorlesungsumdruck |

## Module M1717: Advanced Vadose Zone Hydrology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Modeling Processes in Vadose Zone (L2735) | Recitation Section (small) | 2 | 2 |
| Vadose Zone Hydrology (L2732) | Lecture | 2 | 2 |
| Vadose Zone Hydrology (L2733) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Nima Shokri |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in water and soil<br>Comfortable with math and physics, critical thinking, creative problem solving<br>Analytic skills |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students will learn about soil characterization (solid and liquid phase), the energy state of soil water, the soil water characteristic curve, flow in saturated and unsaturated soil as well as about solute transport in soil |
| *Skills* | Students will work on practical examples modelling transport processes in soil using different quantitative tools including computer simulations and analytical tools. This will help them to apply knowledge in order to solve problems and tasks. |
| **Personal Competence** | |
| *Social Competence* | The module aims at raising awareness and enthusiasm for new knowledge related to water, soil and environment. This will positively contribute to shape their work and life environment. |
| *Autonomy* | The students will be involved in many problem solving exercises. This will contribute toward their willingness to work independently and responsibly. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Report and Presentation |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Civil Engineering: Specialisation Computational Engineering: Elective Compulsory<br>Environmental Engineering: Core Qualification: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

### Course L2735: Modeling Processes in Vadose Zone

| | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Milad Aminzadeh |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Numerical tools will be introduced and used to quantify flow and transport processes in soil |
| **Literature** | NA |

| Course L2732: Vadose Zone Hydrology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Nima Shokri |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Soil solid phase characterization, Soil liquid phase characterization, The energy state of soil water, Soil Water Characteristic Curve, Flow in saturated soil, Flow in unsaturated soil, Solute transport in porous media |
| **Literature** | - Environmental Soil Physics, by Daniel Hillel<br>- Soil Physics, Sixth Edition, by William A. Jury and Robert Horton<br>- Physical Hydrology, Second Edition, by S. Lawrence Dingman<br>- Introduction to Physical Hydrology, by Martin R. Hendriks |

| Course L2733: Vadose Zone Hydrology | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Nima Shokri |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1123: Selected Topics in Environmental Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Environmental Aquatic Chemistry (L1444) | Lecture | 2 | 3 |
| Sludge Treatment (L0520) | Lecture | 2 | 3 |
| Thermal Biomass Utilization (L1767) | Lecture | 2 | 2 |
| Thermal Biomass Utilization (L2386) | Practical Course | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Mathias Ernst |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence**<br>*Knowledge*<br>*Skills*<br>**Personal Competence**<br>*Social Competence*<br>*Autonomy* | |
| **Workload in Hours** | Depends on choice of courses |
| **Credit points** | 6 |
| **Assignment for the Following Curricula** | Environmental Engineering: Core Qualification: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory |

### Course L1444: Environmental Aquatic Chemistry

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Examination Form** | Klausur |
| **Examination duration and scale** | 60 min |
| **Lecturer** | Dr. Klaus Johannsen |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Concentration and activity<br>• Gas-water partitioning<br>• Acid/base equilibria<br>• Alkalinity and acidity<br>• Precipitation/dissolution equilibria<br>• Redox equilibria<br>• Complex formation<br>• Sorption |
| **Literature** | Worch, E.: Hydrochemistry. Basic Concepts and Exercises. De Gruyter, Berlin, 2015 |

| Course L0520: Sludge Treatment | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Examination Form** | Klausur |
| **Examination duration and scale** | 60 min |
| **Lecturer** | Dr. Joachim Behrendt |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Sedimentation characteristic and thickening,<br>Centrifugation,<br>Flotation,<br>Filtration,<br>Aerobic sludge stabilisation,<br>Sludge Digestion,<br>Sludge Disintegration,<br>Sludge Dewatering,<br>Natural Processes for Sludge Treatment,<br>Nutrient Recovery from Sludge,<br>Thermal Processes and Incineration. |
| **Literature** | **Tchobanoglous, George** (Metcalf & Eddy, Inc., ;)<br>Wastewater engineering : treatment and reuse<br>ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk))<br>Boston [u.a.] : McGraw-Hill, 2003<br>TUB_HH_Katalog<br>**Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes**<br>Sludge Treatment and Disposal<br>ISBN 9781843391661<br>IWA Publishing, 2007 |

| Course L1767: Thermal Biomass Utilization | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Klausur |
| **Examination duration and scale** | 60 min |
| **Lecturer** | Prof. Martin Kaltschmitt |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmental basics of all options to provide energy from biomass from a German and international point of view. Additionally different system approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and economic development potentials, and the current and expected future use within the energy system are presented.<br><br>The course is structured as follows:<br><br>• Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course<br>• Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste<br>• Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying<br>• Thermo-chemical conversion of solid biofuels<br>  ◦ Basics of thermo-chemical conversion<br>  ◦ Direct thermo-chemical conversion through combustion: combustion technologies for small and large scale units, electricity generation technologies, flue gas treatment technologies, ashes and their use<br>  ◦ Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels<br>  ◦ Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for the provision of charcoal, oil cleaning technologies, options to use the pyrolysis oil and charcoal as an energy carrier as well as a raw material<br>• Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil seeds and oil fruits, vegetable oil production, production of a biofuel with standardized characteristics (trans-esterification, hydrogenation, co-processing in existing refineries), options to use this fuel, options to use the residues (i.e. meal, glycerine)<br>• Bio-chemical conversion of biomass<br>  ◦ Basics of bio-chemical conversion<br>  ◦ Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic waste fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry<br>  ◦ Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage |
| **Literature** | **Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage** |

| Course L2386: Thermal Biomass Utilization | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Examination Form** | Schriftliche Ausarbeitung |
| **Examination duration and scale** | Protokolle |
| **Lecturer** | Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The experiments of the practical lab course illustrate the different aspects of heat generation from biogenic solid fuels. First, different biomasses (e.g. wood, straw or agricultural residues) will be investigated; the focus will be on the calorific value of the biomass. Furthermore, the used biomass will be pelletized, the pellet properties analysed and a combustion test carried out on a pellet combustion system. The gaseous and solid pollutant emissions, especially the particulate matter emissions, are measured and the composition of the particulate matter is investigated in a further experiment. Another focus of the practical course is the consideration of options for the reduction of particulate matter emissions from biomass combustion. In the practical course, a method for particulate matter reduction will be developed and tested. All experiments will be evaluated and the results presented.<br><br>Within the practical lab course the students discuss different technical-scientific tasks, both subject-specifically and interdisciplinary. They<br>discuss various approaches to solving the problem and advise on the theoretical or practical implementation. |
| **Literature** | - Kaltschmitt, Martin; Hartmann, Hans; Hofbauer, Hermann: Energie aus Biomasse: Grundlagen, Techniken und Verfahren. 3. Auflage. Berlin Heidelberg: Springer Science & Business Media, 2016. -ISBN 978-3-662-47437-2<br>- Versuchsskript |

## Module M0871: Hydrological Systems

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Applied Surface Hydrology (L0289) | Lecture | 2 | 2 |
| Applied Surface Hydrology (L1412) | Project-/problem-based Learning | 1 | 2 |
| Interaction Water - Environment in Fluvial Areas (L0295) | Project-/problem-based Learning | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of Hydromechanics and Hydraulic Engineering: Hydraulic Engineering I and Hydraulic Engineering II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to define the basic concepts of hydrology and water management. They are able to describe and quantify the relevant processes of the hydrological water cycle. Besides, the students know the main aspects of rainfall-run-off-models and are able to theoretically derive established reservoir / storage models and a unit-hydrograph. |
| *Skills* | The students are able to use the basic hydrological concepts and approaches and are able to theoretically derive established reservoir / storage models or a unit-hydrograph as the basis for rainfall-run-off-models. The student are able to explain the basic concepts of measurements of hydrological and hydrodynamic values in nature and are able to perform, analyze and statistically assess these measurements. Furthermore, they are able to apply a hydrological model to basic hydrological problems. |
| **Personal Competence** | |
| *Social Competence* | The students are able to deploy their gained knowledge in applied problems of the hydrology and water management. Additionaly, they will be able to work in team with engineers of other disciplines. |
| *Autonomy* | The students will be able to independently extend their knowledge and apply it to new problems |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | The duration of the examination is 90 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Civil Engineering: Specialisation Computational Engineering: Elective Compulsory<br>Environmental Engineering: Core Qualification: Elective Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

### Course L0289: Applied Surface Hydrology

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | Basics of hydrology:<br>• Hydrological cycle<br>• Data acquisition<br>• Data analyses and statistical assessment<br>• Statistics of extremes<br>• Regionalization methods for hydrological values<br>• Rainfall-run-off modelling on the basis of a unit hydrograph conceps<br>• Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool. |
| **Literature** | http://de.wikipedia.org/wiki/Kalypso_(Software)<br>http://kalypso.bjoernsen.de/<br>http://sourceforge.net/projects/kalypso/ |

| Course L1412: Applied Surface Hydrology | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0295: Interaction Water - Environment in Fluvial Areas | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | A problem based learning course. The problem will be solved by the students more or less self-contained. The topics will be introduced and elaborated over the semester. |
| **Literature** | - |

## Module M1758: Practical module 3 (dual study program, Master's degree)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical term 3 (dual study program, Master's degree) (L2889) | | 0 | 10 |

| | |
|---|---|
| **Module Responsible** | Dr. Henning Haschke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Successful completion of practical module 2 as part of the dual Master's course<br>• course E from the module on interlinking theory and practice as part of the dual Master's course |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students ...<br>• ... combine their comprehensive and specialised engineering knowledge acquired from previous study contents with the strategy-oriented practical knowledge gained from their current field of work and area of responsibility.<br>• ... have a critical understanding of the practical applications of their engineering subject, as well as related fields when implementing innovations. |
| *Skills* | Dual students ...<br>• ... apply specialised and conceptual skills to solve complex, sometimes interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action.<br>• ... implement the university's application recommendations with regard to their current tasks.<br>• ... develop new solutions as well as procedures and approaches to implement operational projects and assignments - even when facing frequently changing requirements and unpredictable changes (systemic skills).<br>• ... can use academic methods to develop new ideas and procedures for operational problems and issues, and to assess these with regard to their usability. |
| **Personal Competence** | |
| *Social Competence* | Dual students ...<br>• ... work responsibly in cross-departmental and interdisciplinary project teams and proactively deal with problems within their team.<br>• ... can promote the professional development of others in a targeted manner.<br>• ... represent complex and interdisciplinary engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders and develop these further together. |
| *Autonomy* | Dual students ...<br>• ... reflect on learning and work processes in their area of responsibility.<br>• ... define goals for new application-oriented tasks, projects and innovation plans while reflecting on potential effects on the company and the public.<br>• ... reflect on the relevance of areas of specialisation and research for work as an engineer, and also implement the university's application recommendations and the associated challenges to positively transfer knowledge between theory and practice. |
| **Workload in Hours** | Independent Study Time 300, Study Time in Lecture 0 |
| **Credit points** | 10 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase. |
| **Assignment for the Following Curricula** | Civil Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Computer Science: Core Qualification: Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Energy Systems: Core Qualification: Compulsory<br>Environmental Engineering: Core Qualification: Compulsory<br>Aircraft Systems Engineering: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Information and Communication Systems: Core Qualification: Compulsory<br>International Management and Engineering: Core Qualification: Compulsory<br>Logistics, Infrastructure and Mobility: Core Qualification: Compulsory<br>Aeronautics: Core Qualification: Compulsory |

| | |
|---|---|
| | Materials Science and Engineering: Core Qualification: Compulsory<br>Materials Science: Core Qualification: Compulsory<br>Mechanical Engineering and Management: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Biomedical Engineering: Core Qualification: Compulsory<br>Microelectronics and Microsystems: Core Qualification: Compulsory<br>Product Development, Materials and Production: Core Qualification: Compulsory<br>Renewable Energies: Core Qualification: Compulsory<br>Naval Architecture and Ocean Engineering: Core Qualification: Compulsory<br>Theoretical Mechanical Engineering: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Water and Environmental Engineering: Core Qualification: Compulsory |

| **Course L2889: Practical term 3 (dual study program, Master's degree)** | |
|---|---|
| **Typ** | |
| **Hrs/wk** | 0 |
| **CP** | 10 |
| **Workload in Hours** | Independent Study Time 300, Study Time in Lecture 0 |
| **Lecturer** | Dr. Henning Haschke |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | **Company onboarding process**<br>• Assigning a future professional field of activity as an engineer (M.Sc.) and associated fields of work<br>• Extending responsibilities and authorisation of the dual student within the company up to the intended first assignment after completing their studies<br>• Working responsibly in a team; project responsibility within own area - as well as across divisions and companies if necessary<br>• Scheduling the final practical module with a clear correlation to work structures<br>• Internal agreement on a potential topic or innovation project for the Master's dissertation<br>• Planning the Master's dissertation within the company in cooperation with TU Hamburg<br>• Scheduling the examination phase/subsequent study semester<br>**Operational knowledge and skills**<br>• Company-specific: dealing with change, project and team development, responsibility as an engineer in their future field of work (M.Sc.), dealing with complex contexts, frequent and unpredictable changes, developing and implementing innovative solutions<br>• Specialising in one field of work (final dissertation)<br>• Systemic skills<br>• Implementing the university's application recommendations (theory-practice transfer) in corresponding work and task areas across the company<br>**Sharing/reflecting on learning**<br>• E-portfolio<br>• Relevance of study content and personal specialisation when working as an engineer<br>• Relevance of research and innovation when working as an engineer |
| **Literature** | • Studierendenhandbuch<br>• betriebliche Dokumente<br>• Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer |

## Specialization Energy and Resources

### Module M1724: Smart Monitoring

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Smart Monitoring (L2762) | Integrated Lecture | 2 | 2 |
| Smart Monitoring (L2763) | Recitation Section (small) | 2 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Kay Smarsly |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpful. Interest in modern research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deepen skills of scientific working, are required. Basic knowledge in scientific writing and good English skills. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students will become familiar with the principles and practices of smart monitoring. The students will be able to design decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built and in the natural environment. In addition, the students will learn to design and to implement intelligent sensor systems using state-of-the-art data analysis techniques, modern software design concepts, and embedded computing methodologies. Besides lectures, project work is also part of this module, which will be conducted throughout the semester and will contribute to the grade. In small groups, the students will design smart monitoring systems that integrate a number of “intelligent” sensors to be implemented by the students. Specific focus will be put on the application of machine learning techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as bridges or slopes, or on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper. All students of this module will “automatically” participate with their smart monitoring system in the annual "Smart Monitoring" competition. The written papers and oral examinations form the final grades. The module will be taught in English. Limited enrollment. |
| *Skills* | |
| **Personal Competence** | |
| *Social Competence* | |
| *Autonomy* | |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | 10 pages of work with 15-minute oral presentation |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>Mechatronics: Technical Complementary Course: Elective Compulsory<br>Mechatronics: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory |

| Course L2762: Smart Monitoring | |
|---|---|
| **Typ** | Integrated Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kay Smarsly |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment. |
| **Literature** | |

| Course L2763: Smart Monitoring | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kay Smarsly |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted throughout the semester, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the “Smart Monitoring” competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature. |
| **Literature** | |

## Module M0518: Waste and Energy

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Waste Recycling Technologies (L0047) | Lecture | 2 | 2 |
| Waste Recycling Technologies (L0048) | Recitation Section (small) | 1 | 2 |
| Waste to Energy (L0049) | Project-/problem-based Learning | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Kerstin Kuchta |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of process engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe and explain in detail techniques, processes and concepts for treatment and energy recovery from wastes. |
| *Skills* | The students are able to select suitable processes for the treatment and energy recovery of wastes. They can evaluate the efforts and costs for processes and select economically feasible treatment Concepts. Students are able to evaluate alternatives even with incomplete information. Students are able to prepare systematic documentation of work results in form of reports, presentations and are able to defend their findings in a group. |
| **Personal Competence** | |
| *Social Competence* | Students can participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development of collegues. Furthermore, they can give and accept professional constructive criticism. |
| *Autonomy* | Students can independently tap knowledge of the subject area and transform it to new questions. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: Yes; Bonus: 20 %; Form: Written elaboration; Description: |
| **Examination** | Presentation |
| **Examination duration and scale** | PowerPoint presentation (10-15 minutes) |
| **Assignment for the Following Curricula** | Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory |

| Course L0047: Waste Recycling Technologies | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Fundamentals on primary and secondary production of raw materials (steel, aluminum, phosphorous, copper, precious metals, rare metals)<br>• Use and demand of metals and minerals in industry and society<br>• collection systems and concepts<br>• quota and efficiency<br>• Advanced sorting technologies<br>• mechanical pretreatment<br>• advanced treatment<br>• Chemical analysis of Critical Materials in post-consumer products<br>• Analytical tools in Resource Management (Material Flow Analysis, Recycling Performance Indicators, Criticality Assessment, statistical analysis of uncertainties) |
| **Literature** | |

| Course L0048: Waste Recycling Technologies | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Fundamentals on primary and secondary production of raw materials (steel, aluminum, phosphorous, copper, precious metals, rare metals)<br>• Use and demand of metals and minerals in industry and society<br>• collection systems and concepts<br>• quota and efficiency<br>• Advanced sorting technologies<br>• mechanical pretreatment<br>• advanced treatment<br>• Chemical analysis of Critical Materials in post-consumer products<br>• Analytical tools in Resource Management (Material Flow Analysis, Recycling Performance Indicators, Criticality Assessment, statistical analysis of uncertainties) |
| **Literature** | |

| Course L0049: Waste to Energy | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Rüdiger Siechau |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Project-based lecture<br>• Introduction into the " Waste to Energy " consisting of:<br>  ◦ Thermal Process ( incinerator , RDF combustion )<br>  ◦ Biological processes ( Wet-/Dryfermentation )<br>  ◦ technology , energy , emissions, approval , etc.<br>• Group work<br>  ◦ design of systems/plants for energy recovery from waste<br>  ◦ The following points are to be processed :<br>  ▪ Input: waste ( fraction collection and transportation, current quantity , material flows , possible amount of development )<br>  ▪ Plant (design, process diagram , technology, energy production )<br>  ▪ Output ( energy quantity / type , by-products )<br>  ▪ Costs and revenues<br>  ▪ Climate and resource protection ( CO2 balance , substitution of primary raw materials / fossil fuels )<br>  ▪ Location and approval (infrastructure , expiration authorization procedure)<br>  ▪ Focus at the whole concept ( advantages, disadvantages , risks and opportunities , discussion )<br>• Grading: No Exam , but presentation of the results of the working group |
| **Literature** | **Literatur:**<br>Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010<br>Powerpoint-Folien in Stud IP<br><br>**Literature:**<br>Introduction to Waste Management; Kranert Martin , Klaus Cord - Landwehr (Ed. ), Vieweg + Teubner Verlag , 2010<br>PowerPoint slides in Stud IP |

## Module M1709: Applied optimization in energy and process engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Applied optimization in energy and process engineering (L2693) | Integrated Lecture | 2 | 3 |
| Applied optimization in energy and process engineering (L2695) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Mirko Skiborowski |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals in the field of mathematical modeling and numerical mathematics, as well as a basic understanding of process engineering processes.<br><br>In particular the contents of the module Process and Plant Engineering II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The module provides a general introduction to the basics of applied mathematical optimization and deals with application areas on different scales from the identification of kinetic models, to the optimal design of unit operations and the optimization of entire (sub)processes, as well as production planning. In addition to the basic classification and formulation of optimization problems, different solution approaches are discussed and tested during the exercises. Besides deterministic gradient-based methods, metaheuristics such as evolutionary and genetic algorithms and their application are discussed as well.<br><br>• Introduction to Applied Optimization<br><br>• Formulation of optimization problems<br><br>• Linear Optimization<br><br>• Nonlinear Optimization<br><br>• Mixed-integer (non)linear optimization<br><br>• Multi-objective optimization<br><br>• Global optimization |
| *Skills* | After successful participation in the module "Applied Optimization in Energy and Process Engineering", students are able to formulate the different types of optimization problems and to select appropriate solution methods in suitable software such as Matlab and GAMS and to develop improved solution strategies. Furthermore, students will be able to interpret and critically examine the results accordingly. |
| **Personal Competence** | |
| *Social Competence* | Students are capable of:<br><br>•develop solutions in heterogeneous small groups |
| *Autonomy* | Students are capable of:<br><br>•taping new knowledge on a special subject by literature research |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Oral exam |
| **Examination duration and scale** | 35 min |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory<br>Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory<br>Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory |

| Course L2693: Applied optimization in energy and process engineering | |
|---|---|
| **Typ** | Integrated Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Mirko Skiborowski |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | The lecture offers a general introduction to the basics and possibilities of applied mathematical optimization and deals with application areas on different scales from kinetics identification, optimal design of unit operations to the optimization of entire (sub)processes, and production planning. In addition to the basic classification and formulation of optimization problems, different solution approaches are discussed. Besides deterministic gradient-based methods, metaheuristics such as evolutionary and genetic algorithms and their application are discussed as well.<br>- Introduction to Applied Optimization<br>- Formulation of optimization problems<br>- Linear Optimization<br>- Nonlinear Optimization<br>- Mixed-integer (non)linear optimization<br>- Multi-objective optimization<br>- Global optimization |
| **Literature** | Weicker, K., Evolutionäre Algortihmen, Springer, 2015<br>Edgar, T. F., Himmelblau D. M., Lasdon, L. S., Optimization of Chemical Processes, McGraw Hill, 2001<br>Biegler, L. Nonlinear Programming - Concepts, Algorithms, and Applications to Chemical Processes, 2010<br>Kallrath, J. Gemischt-ganzzahlige Optimierung: Modellierung in der Praxis, Vieweg, 2002 |

| Course L2695: Applied optimization in energy and process engineering | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Mirko Skiborowski |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1899: Study work Energy and Ressources

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|

| | |
|---|---|
| **Module Responsible** | Dozenten des Studiengangs |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can demonstrate their detailed knowledge in an area of energy and resource management. The students are qualified to project energy technology and especially resource technology projects and to independently define research tasks for the theoretical and experimental investigation of material and energy issues. They are able to give examples of the state of development and application and to discuss these critically, taking into account current problems and framework conditions in science and society. The students are able to independently define a solution strategy for a basic, application-oriented or practical problem from the field of resource and energy technology and to outline individual solution approaches. In doing so, they are able to proceed in a theory-oriented manner and include current safety, ecological, ethical and economic aspects according to the state of the art in science and associated social discussions.<br><br>They can use the scientific working techniques they have chosen for their own project work, they can present them in detail and critically discuss them. |
| *Skills* | Students are able to independently select methodological approaches for project work and justify this selection in terms of content. They can explain how they relate approaches or methods to the specific field of application in a solution-oriented manner and adapt them to the application context. They can outline the main points and further developments that go beyond the project. |
| **Personal Competence** | |
| *Social Competence* | Students are able to prepare the relevance and cut of their project task, the work steps and sub-problems for discussion and debate in larger groups, guide the discussions and give feedback to colleagues on their projects. |
| *Autonomy* | The students are able to independently plan and document the work steps and processes necessary to complete the coursework, taking into account specified deadlines. This includes being able to obtain current scientific information in a goal-oriented manner. Furthermore, they are able to obtain feedback on the progress of work from experts in the field in order to achieve high-quality work results based on the state of the art in science and technology. |
| **Workload in Hours** | Independent Study Time 360, Study Time in Lecture 0 |
| **Credit points** | 12 |
| **Course achievement** | None |
| **Examination** | Study work |
| **Examination duration and scale** | depending on task |
| **Assignment for the Following Curricula** | Environmental Engineering: Specialisation Energy and Resources: Compulsory |

## Module M1354: Advanced Fuels

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Second generation biofuels and electricity based fuels (L2414) | Lecture | 2 | 2 |
| Carbon dioxide as an economic determinant in the mobility sector (L1926) | Lecture | 1 | 1 |
| Mobility and climate protection (L2416) | Recitation Section (small) | 2 | 2 |
| Sustainability aspects and regulatory framework (L2415) | Lecture | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Bachelor degree in Process Engineering, Bioprocess Engineering or Energy- and Environmental Engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Within the module, students learn about different provision pathways for the production of advanced fuels (biofuels like e.g. alcohol-to-jet; electricity-based fuels like e.g. power-to-liquid). The different processes chains are explained and the regulatory framework for sustainable fuel production is examined. This includes, for example, the requirements of the Renewable Energies Directive II and the conditions and aspects for a market ramp-up of these fuels. For the holistic assessment of the various fuel options, they are also examined under environmental and economic factors. |
| *Skills* | After successfully participating, the students are able to solve simulation and application tasks of renewable energy technology:<br>• Module-spanning solutions for the design and presentation of fuel production processes resp. the fuel provision chains<br>• Comprehensive analysis of various fuel production options in technical, ecological and economic terms<br>Through active discussions of the various topics within the lectures and exercises of the module, the students improve their understanding and application of the theoretical foundations and are thus able to transfer the learned to the practice. |
| **Personal Competence** | |
| *Social Competence* | The students can discuss scientific tasks in a subject-specific and interdisciplinary way and develop joint solutions. |
| *Autonomy* | The students are able to access independent sources about the questions to be addressed and to acquire the necessary knowledge. They are able to assess their respective learning situation concretely in consultation with their supervisor and to define further questions and solutions. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |

**Course achievement**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| Yes | 20 % | Written elaboration | Details werden in der ersten Veranstaltung bekannt gegeben. |

| | |
|---|---|
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory<br>Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Energy and Bioprocess Technology: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical and Bio process Engineering: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory<br>Aircraft Systems Engineering: Core Qualification: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory<br>Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory<br>Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory<br>Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory |

| Course L2414: Second generation biofuels and electricity based fuels | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Martin Kaltschmitt |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | • General overview of various power-based fuels and their process paths, including power-to-liquid process (Fischer-Tropsch synthesis, methanol synthesis), power-to-gas (Sabatier process)<br>• Origin, production and use of these fuels |
| **Literature** | • Vorlesungsskript |

| Course L1926: Carbon dioxide as an economic determinant in the mobility sector | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Karsten Wilbrand |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | • General overview of various advanced biofuels and their process pathways (including gas-to-liquid, HEFA and Alcohol-to-Jet processes)<br>• Origin, production and use of these fuels |
| **Literature** | • Babu, V.: Biofuels Production. Beverly, Mass: Scrivener [u.a.], 2013<br>• Olsson, L.: Biofuels. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg, 2007<br>• William, L. L.: Distillation Design and Control Using Aspen Simulation; ISBN-10: 0-471-77888-5<br>• Perry, R.; Green, R.: Perry's Chemical Engineers' Handbook, 8th Edition, McGraw Hill Professional, 20<br>• Sinnot, R. K.: Chemical Engineering Design, Elsevier, 2014<br>• Kaltschmitt, M.; Neuling, U. (Ed.): Biokerosene - Status and Prospects; Springer, Berlin, Heidelberg, 2018 |

| Course L2416: Mobility and climate protection | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Benedikt Buchspies, Dr. Karsten Wilbrand |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | Application of the acquired theoretical knowledge from the respective lectures on the basis of concrete tasks from practice<br>• Design and simulation of sub-processes of production processes in Aspen Plus ®<br>• Ecological and economic analysis of fuel supply paths<br>• Classification of case studies into applicable regulations |
| **Literature** | • Skriptum zur Vorlesung<br>• Aspen Plus® - Aspen Plus User Guide |

| Course L2415: Sustainability aspects and regulatory framework | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Benedikt Buchspies |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | Holistic examination of the different fuel paths with the following main topics, among others:<br>• Consideration of the environmental impact of the various alternative fuels<br>• Economic consideration of the different alternative fuels<br>• Regulatory framework for alternative fuels<br>• Certification of alternative fuels<br>• Market introduction models of alternative fuels |
| **Literature** | • European Commission - Joint Research Center (2010): International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. Joint Research Center (JRC) Institut for Environment and Sustainability, Luxembourg<br>• Richtlinie (EU) 2018/2001 des Europäischen Parlaments und des Rates vom 11. Dezember 2018 zur Förderung der Nutzung von Energie aus erneuerbaren Quellen |

## Module M1125: Bioresources and Biorefineries

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Biorefinery Technology (L0895) | Lecture | 2 | 2 |
| Biorefinery Technologie (L0974) | Recitation Section (small) | 1 | 1 |
| Bioresource Management (L0892) | Lecture | 2 | 2 |
| Bioresource Management (L0893) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Dr. Ina Körner |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics on engineering;<br>Basics of waste and energy management |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can give on overview on principles and theories in the field's bioresource management and biorefinery technology and can explain specialized terms and technologies. |
| *Skills* | Students are capable of applying knowledge and know-how in the field's bioresource management and biorefinery technology in order to perform technical and regional-planning tasks. They are also able to discuss the links to waste management, energy management and biotechnology. |
| **Personal Competence** | |
| *Social Competence* | Students can work goal-oriented with others and communicate and document their interests and knowledge in acceptable way. |
| *Autonomy* | Students are able to solve independently, with the aid of pointers, practice-related tasks bearing in mind possible societal consequences. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory |

| Course L0895: Biorefinery Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Ina Körner |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | The Europe 2020 strategy calls for bioeconomy as the key for smart and green growth of today. Biorefineries are the fundamental part on the way to convert the use of fossil-based society to bio-based society. For this reason, agriculture and forestry sectors are increasingly deliver bioresources. It is not only for their traditional applications in the food and feed sectors such as pulp or paper and construction material productions, but also to produce bioenergy and bio-based products such as bio-plastics. However although bioresources are renewable, they are considered as limited resources as well. The bioeconomy's limitation factor is the availability land on our world. In the context of the development of the bioeconomy, the sustainable and reliable supply of noon-food biomass feedstock is a critical success factor for the long-term perspective of bioenergy and other bio-based products production. Biorefineries are complex of technologies and process cascades using the available primary, secondary and tertiary bioresources to produce a multitude of products - a product mix from material and energy products.<br><br>The lecture gives an overview on biorefinery technology and shall contribute to promotion of international biorefinery developments.<br><br>Lectures:<br><br>• What is a biorefinery: Overview on basic organic substrates and processes which lead to material and energy products<br>• The way from a fossil based to a biobased economy in the 21st century<br>• The worlds most advanced biorefinery<br>• Presentation of various biorefinery systems and their products (e.g. lignocellulose biorefinery, green biorefinery, whole plant biorefinery, civilization biorefinery)<br>• Example projects (e.g. combination of anaerobic digestion and composting in practice; demonstration project in Hamburgs city quarter Jenfelder Au)<br><br>The lectures will be accompanied by technical tours. Optional it is also possible to visit more biorefinery lectures in the University of Hamburg (lectures in German only).<br><br>In the exercise students have the possibility to work in groups on a biorefinery project or to work on a student-specific task. |
| **Literature** | Biorefineries - Industrial Process and Products - Status Qua and Future directions by Kamm, Gruber and Kamm (2010); Wiley VCH, available on-line in TUHH-library<br><br>Powerpoint-Präsentations / selected Publications / further recommendations depending on the actual developments<br><br>Industrial Biorefineries and White Biorefinery, by Pandey, Höfer, Larroche, Taherzadeh, Nampoothiri (Eds.); (2014 book development in progress) |

| Course L0974: Biorefinery Technologie | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Ina Körner |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | 1. ) Selection of a topic within the thematic area "Biorefinery Technologie" from a given list or self-selected.<br><br>2.) Self-dependent recherches to the topic.<br><br>3.) Preparation of a written elaboration.<br><br>4.) Presentation of the results in the group. |
| **Literature** | Vom Thema abhängig. Eigene Recherchen nötig.<br><br>Depending on the topic. Own recheches necassary. |

| Course L0892: Bioresource Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Ina Körner |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | In the context of limited fossil resources, climate change mitigation and increasing population growth, Bioresources has a special role. They have to feed the population and in the same time they are important for material production such as pulp and paper or construction materials. Moreover they become more and more important in chemical industry and in energy provision as fossil substitution. Although Bioresources are renewable, they are also considered as limited resources. The availability of land on our planet is the main limitation factor. The sustainable and reliable supply of non-food biomass feedstock is a critical for successful and long term perspective on production of bioenergy and other bio-based products. As the consequence, the increasing competition and shortages continue to happen at the traditional sectors. On the other side, huge unused but potentials residue on waste and wastewater sector exist. Nowadays, a lot of activities to develop better processes, to create new bio-based products in order to become more efficient, the inclusion of secondary and tertiary bio-resources in the valorisation chain are going on.<br><br>The lecture deals with the current state-of-the-art of bioresource management. It shows deficits and potentials for improvement especially in the sector of utilization of organic residues for material and energy generation:<br><br>*Lectures on:*<br><br>• Bioresource generation and utilization including lost potentials today<br>• Basic biological, mechanical, physico-chemical and logistical processes<br>• The conflict of material vs. energy generation from wood / waste wood<br>• The basics of pulp & paper production including waste paper recycling<br>• The Pros and Cons from biogas and compost production<br><br>*Special lectures by invited guests from research and practice:*<br><br>• Pathways of waste organics on the example of Hamburg`s City Cleaning Company<br>• Utilization options of landscaping materials on the example of grass<br>• Increase of process efficiency of anaerobic digestions<br>• Decision support tools on the example of an municipality in Indonesia<br><br>*Optional: Technical visits* |
| **Literature** | Power-Point presentations in STUD-IP |

| Course L0893: Bioresource Management | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Ina Körner |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M2004: Sustainable Circular Economy

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Circular Economy (L3264) | Seminar | 2 | 3 |
| Environment and Sustainability (L0319) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Kerstin Kuchta |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe single techniques and to give an overview for the field of safety and risk assessment, Circular Economy as well as environmental and sustainable engineering, in detail:<br>• basics in safety and reliability of technical facilities<br>• risk assessment and reliability analysis methods<br>• Circularity of material<br>• Identification and evaluation of material flows<br>• energy production and supply<br>• sustainable product design |
| *Skills* | Students are able apply interdisciplinary system-oriented methods for Circularity and risk assessment as well as sustainability reporting. They can evaluate the effort and costs for processes and select economically feasible treatment concepts. |
| **Personal Competence** | |
| *Social Competence* | |
| *Autonomy* | Students can gain knowledge of the subject area from given sources and transform it to new questions. Furthermore, they can define targets for new application or research-oriented duties in for risk management and sustainability concepts accordance with the potential social, economic and cultural impact. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Elaboration and presentation (45 minutes in groups) |
| **Assignment for the Following Curricula** | Civil Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Management and Controlling: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical and Bio process Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Production: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Materials: Elective Compulsory<br>Water and Environmental Engineering: Core Qualification: Compulsory |

### Course L3264: Circular Economy

| | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Marco Ritzkowski |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

| Course L0319: Environment and Sustainability | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | This course presents actual methodologies and examples of environmental relevant, sustainable technologies, concepts and strategies in the field of energy supply, product design, water supply, waste water treatment or mobility.<br><br>The following list shows examples:<br><br>• Production and use of biochar<br>• Energy production with algae<br>• Environmentally friendly product design<br>• Clean development mechanisms<br>• Democracy and energy<br>• Alternative mobility |
| **Literature** | Wird in der Veranstaltung bekannt gegeben. |

## Module M2006: Waste Treatment and Recycling

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Planning of waste treatment plants (L3267) | Project-/problem-based Learning | 3 | 3 |
| Recycling technologies and thermal waste treatment (L3265) | Lecture | 2 | 2 |
| Recycling technologies and thermal waste treatment (L3266) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Kerstin Kuchta |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Basics of thermo dynamics<br>• Basics of fluid dynamics<br>• fluid dynamics chemistry |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can name, describe current issue and problems in the field of waste treatment (mechanical, chemical and thermal) and contemplate them in the context of their field.<br><br>The industrial application of unit operations as part of process engineering is explained by actual examples of waste technologies . Compostion, particle sizes, transportation and dosing of wastes are described as important unit operations .<br><br>Students will be able to design and design waste treatment technology equipment. |
| *Skills* | The students are able to select suitable processes for the treatment of wastes or raw material with respect to their characteristics and the process aims. They can evaluate the efforts and costs for processes and select economically feasible treatment concepts. |
| **Personal Competence** | |
| *Social Competence* | Students can<br><br>• respectfully work together as a team and discuss technical tasks<br>• participate in subject-specific and interdisciplinary discussions,<br>• develop cooperated solutions<br>• promote the scientific development and accept professional constructive criticism. |
| *Autonomy* | Students can independently tap knowledge of the subject area and transform it to new questions. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical and Bio process Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory<br>Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

| Course L3267: Planning of waste treatment plants | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Rüdiger Siechau |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | The focus is on getting to know the organization and practice of waste management companies. Topics such as planning, financing and logistics will be discussed and there will be an excursion (waste incineration plant, vehicle fleet and collection systems / containers).<br><br>Project based learning: You will be given a task to work on independently in groups of 4 to 6 students. All tools and data needed for the project work will be discussed in the lecture "Recycling Technologies and Thermal Waste Treatment". Course documents can be downloaded from StudIP. Communication during the project work also takes place via StudIP. |
| **Literature** | • Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010<br>• PowerPoint Präsentationen in Stud IP |

| Course L3265: Recycling technologies and thermal waste treatment | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Introduction, actual state-of-the-art of waste incineration, aims. legal background, reaction principals<br>• basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition<br>• Incineration techniques: grate firing, ash transfer, boiler<br>• Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination<br>• Ash treatment: Mass, quality, treatment concepts, recycling, disposal |
| **Literature** | Thomé-Kozmiensky, K. J. (Hrsg.): Thermische Abfallbehandlung Bande 1-7. EF-Verlag für Energie- und Umwelttechnik, Berlin, 196 - 2013. |

| Course L3266: Recycling technologies and thermal waste treatment | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Specialization Environment and Climate

### Module M1724: Smart Monitoring

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Smart Monitoring (L2762) | Integrated Lecture | 2 | 2 |
| Smart Monitoring (L2763) | Recitation Section (small) | 2 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Kay Smarsly |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpful. Interest in modern research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deepen skills of scientific working, are required. Basic knowledge in scientific writing and good English skills. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence**<br>*Knowledge* | The students will become familiar with the principles and practices of smart monitoring. The students will be able to design decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built and in the natural environment. In addition, the students will learn to design and to implement intelligent sensor systems using state-of-the-art data analysis techniques, modern software design concepts, and embedded computing methodologies. Besides lectures, project work is also part of this module, which will be conducted throughout the semester and will contribute to the grade. In small groups, the students will design smart monitoring systems that integrate a number of “intelligent” sensors to be implemented by the students. Specific focus will be put on the application of machine learning techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as bridges or slopes, or on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper. All students of this module will “automatically” participate with their smart monitoring system in the annual "Smart Monitoring" competition. The written papers and oral examinations form the final grades. The module will be taught in English. Limited enrollment. |
| *Skills*<br>**Personal Competence**<br>*Social Competence*<br>*Autonomy* | |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | 10 pages of work with 15-minute oral presentation |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>Mechatronics: Technical Complementary Course: Elective Compulsory<br>Mechatronics: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory |

| Course L2762: Smart Monitoring | |
|---|---|
| **Typ** | Integrated Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kay Smarsly |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment. |
| **Literature** | |

| Course L2763: Smart Monitoring | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kay Smarsly |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted throughout the semester, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the “Smart Monitoring” competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature. |
| **Literature** | |

## Module M0858: Coastal Hydraulic Engineering I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Basics of Coastal Engineering (L0807) | Lecture | 3 | 4 |
| Basics of Coastal Engineering (L1413) | Project-/problem-based Learning | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of hydraulic engineering, hydrology and hydromechanics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to define and explain the basic concepts of coastal engineering and port engineering. They are able to apply the concepts to selected practical problems of coastal engineering. Students can define and determine the basics for design and dimensioning of coastal engineering constructions. |
| *Skills* | The students are capable to apply basic design approaches to selected and pre-defined design tasks in coastal engineering. |
| **Personal Competence** | |
| *Social Competence* | The students are able to deploy their gained knowledge in applied problems such as the design of coastal protection structures. Additionaly, they will be able to work in team with engineers of other disciplines, for instance designing of coastal breakwaters. |
| *Autonomy* | The students will be able to independently extend their knowledge and applyit to new problems. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | The duration of the examination is 2 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Coastal Engineering: Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Compulsory<br>Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory |

| Course L0807: Basics of Coastal Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Basics of planning and design<br>  ◦ Water levels<br>  ◦ Currents<br>  ◦ Waves<br>  ◦ Ice<br>• Planning and Design in Coastal Engineering<br>  ◦ Functional and constructional design<br>  ◦ Determination of design parameters<br>  ◦ Design-approaches<br>  ▪ Filter<br>  ▪ Rubble mound constructions<br>  ▪ Piles<br>  ▪ Vertical constructions |
| **Literature** | Coastal Engineering Manual, CEM<br><br>Vorlesungsumdruck |

| Course L1413: Basics of Coastal Engineering | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1721: Water and Environment: Theory and Application

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Water and Environment (L2754) | Project-/problem-based Learning | 3 | 4 |
| Water and Environment (L2753) | Lecture | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Nima Shokri |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in water and environmental research, Hydrology |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Common research tools and techniques together with the fundamental knowledge relevant to multi-scale and multi-phase challenges present in water and environmental research will be discussed in this module. Both theory and application will be considered. |
| *Skills* | In addition to the fundamental knowledge, the students will be exposed to several analytical, experimental and numerical tools and techniques relevant to water and environmental research at different scales. This will provide the students with an excellent opportunity to improve their skills on multiple fronts which will be useful in their future career. |
| **Personal Competence** | |
| *Social Competence* | Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module. |
| *Autonomy* | The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Report and Presentation |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Compulsory |

### Course L2754: Water and Environment

| | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Dr. Salome Shokri-Kuehni |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

### Course L2753: Water and Environment

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Nima Shokri |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Research based learning: The students will be engaged in active research focused on water and environmental related challenges. The required knowledge and tools will be discussed during the semester. |
| **Literature** | NA |

## Module M1900: Study work Environment and Climate

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|

| | |
|---|---|
| **Module Responsible** | Dozenten des Studiengangs |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to demonstrate their detailed knowledge in an area of environmental engineering. The students are qualified to project climate and environmental protection-oriented projects and to independently define research tasks for the theoretical and experimental investigation of environmental problems. They are able to give examples of the state of development and application and discuss these critically, taking into account current problems and framework conditions in science and society. The students are able to independently define a solution strategy for a basic, application-oriented or practical problem from the field of environmental engineering and to outline individual solution approaches. In doing so, they are able to proceed in a theory-oriented manner and include current safety, ecological, ethical and economic aspects according to the state of the art in science and related social discussions.<br><br>They can use the scientific working techniques they have chosen for their own project work, they can present them in detail and critically discuss them. |
| *Skills* | Students are able to independently select methodological approaches for project work and justify this selection in terms of content. They can explain how they relate approaches or methods to the specific field of application in a solution-oriented manner and adapt them to the application context. They can outline the main points and further developments that go beyond the project. |
| **Personal Competence** | |
| *Social Competence* | Students are able to prepare the relevance and cut of their project task, the work steps and sub-problems for discussion and debate in larger groups, guide the discussions and give feedback to colleagues on their projects. |
| *Autonomy* | The students are able to independently plan and document the work steps and processes necessary to complete the coursework, taking into account specified deadlines. This includes being able to obtain current scientific information in a goal-oriented manner. Furthermore, they are able to obtain feedback on the progress of work from experts in the field in order to achieve high-quality work results based on the state of the art in science and technology. |
| **Workload in Hours** | Independent Study Time 360, Study Time in Lecture 0 |
| **Credit points** | 12 |
| **Course achievement** | None |
| **Examination** | Study work |
| **Examination duration and scale** | depending on task |
| **Assignment for the Following Curricula** | Environmental Engineering: Specialisation Environment and Climate: Compulsory |

## Module M0949: Rural Development and Resources Oriented Sanitation for different Climate Zones

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Rural Development and Resources Oriented Sanitation for different Climate Zones (L0942) | Seminar | 2 | 3 |
| Rural Development and Resources Oriented Sanitation for different Climate Zones (L0941) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf Otterpohl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of the global situation with rising poverty, soil degradation, lack of water resources and sanitation |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can describe resources oriented wastewater systems mainly based on source control in detail. They can comment on techniques designed for reuse of water, nutrients and soil conditioners.<br><br>Students are able to discuss a wide range of proven approaches in Rural Development from and for many regions of the world. |
| *Skills* | Students are able to design low-tech/low-cost sanitation, rural water supply, rainwater harvesting systems, measures for the rehabilitation of top soil quality combined with food and water security. Students can consult on the basics of soil building through “Holisitc Planned Grazing” as developed by Allan Savory. |
| **Personal Competence** | |
| *Social Competence* | The students are able to develop a specific topic in a team and to work out milestones according to a given plan. |
| *Autonomy* | Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information will be provided at the beginning of the smester. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

### Course L0942: Rural Development and Resources Oriented Sanitation for different Climate Zones

| | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Central part of this module is a group work on a subtopic of the lectures. The focus of these projects will be based on an interview with a target audience, practitioners or scientists.<br>• The group work is divided into several Milestones and Assignments. The outcome will be presented in a final presentation at the end of the semester. |
| **Literature** | • J. Lange, R. Otterpohl 2000: Abwasser - Handbuch zu einer zukunftsfähigen Abwasserwirtschaft. Mallbeton Verlag (TUHH Bibliothek)<br>• Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download)<br>• Schober, Sabine: WTO/TUHH Award winning Terra Preta Toilet Design: http://youtu.be/w_R09cYq6ys |

| Course L0941: Rural Development and Resources Oriented Sanitation for different Climate Zones | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Living Soil - THE key element of Rural Development<br>• Participatory Approaches<br>• Rainwater Harvesting<br>• Ecological Sanitation Principles and practical examples<br>• Permaculture Principles of Rural Development<br>• Performance and Resilience of Organic Small Farms<br>• Going Further: The TUHH Toolbox for Rural Development<br>• EMAS Technologies, Low cost drinking water supply |
| **Literature** | • Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk<br>• Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press |

## Module M0859: Coastal Hydraulic Engineering II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Coastal- and Flood Protection (L0808) | Lecture | 2 | 3 |
| Coastal- and Flood Protection (L1415) | Project-/problem-based Learning | 1 | 1 |
| Maintenance and Defence of Flood Protection Structures (L1411) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Coastal Engineering I |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students have the capability to define and explain in detail the important aspects of erosion protection and flood protection and are able to apply the aspects to practical coastal protection problems. They are able to design and dimension important coastal protection measures from the functional and from the constructional point of view. |
| *Skills* | The students are able to select design approaches for the functional and constructional design of erosion and flood protection measures and apply these approaches to practical design tasks. |
| **Personal Competence** | |
| *Social Competence* | The students are able to deploy their gained knowledge in applied problems such as the functional and constructive design of coastal and flood protection structures. Additionaly, they will be able to work in team with engineers of other disciplines. |
| *Autonomy* | The students will be able to independently extend their knowledge and apply it to new problems. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | The duration of the examination is 130 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Coastal Engineering: Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory |

| Course L0808: Coastal- and Flood Protection | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Protection of sandy coasts<br>• Sediment transport<br>• Morphology<br>• Technical solution for the protection of sandy coasts<br>  ◦ Construction in direction of the coast<br>  ◦ Constructions perpendicular to the coast<br>  ◦ Other Concepst<br>• Calculation approaches and numerical models<br>Flood Protection<br>• Classification of constructions / measures<br>• Dikes<br>• Dunes<br>• Foreland - constructions<br>• Flood-Protection Walls<br>• Drainage of the hinterland |
| **Literature** | Vorlesungsumdruck<br>Coastal Engineering Manual CEM |

| Course L1415: Coastal- and Flood Protection | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1411: Maintenance and Defence of Flood Protection Structures | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Olaf Müller |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Dike protection<br>• Maintennance of flood protection measures |
| **Literature** | Vorlesungsumdruck |

## Module M1720: Emerging Trends in Environmental Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Environmental Research Trends (L2752) | Seminar | 2 | 2 |
| Microplastics in Environment (L2750) | Lecture | 2 | 2 |
| Scientific Communication and Methods (L2751) | Lecture | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Nima Shokri |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge on water, soil and environmental research. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students will be exposed to up-to-date research topics focused on soil, water and climate related challenges with a particular focus on the effects of microplastics in environment. Data analysis, data measurement, curation and presentation will be other skills that the students will develop in this module. |
| *Skills* | Students' research skills will be improved in this module. How to prepare and deliver an effective presentation, how to write an abstract, research paper and proposal will be discussed in this module. Moreover, through Research-Based Learning approaches, the students will be exposed to current research trends in environmental engineering. |
| **Personal Competence** | |
| *Social Competence* | Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module. |
| *Autonomy* | The students will be involved in writing individual reports and presentation. This will contribute to the students' ability and willingness to work independently and responsibly. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Report and Presentation |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory |

| Course L2752: Environmental Research Trends | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Salome Shokri-Kuehni |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Introduction - course objectives, expectations and format<br>Analyzing the Audience, purpose and occasion<br>Constructing and delivering effective technical presentations<br>How to write an abstract<br>How to write a scientific paper<br>Developing competitive and persuasive research proposals<br>Databases and resources available for water and environmental research<br>Individual proposal on water and environmental research<br>Individual project on water and environmental research<br>Presentation on water and environmental research |
| **Literature** | • The Craft of Scientific Writing Fourth edition<br>Author: Michael Alley<br>Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9<br>• Supplemental materials and web links which will be available to registered students. |

| Course L2750: Microplastics in Environment | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Nima Shokri |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | - Introduction, objectives, expectations, format, importance<br>- Sources of microplastics in environment<br>- Microplastics sampling; Characterization of microplastics<br>- Distribution of microplastics in terrestrial environments<br>- Fate of microplastics in terrestrial environments<br>- Project discussion<br>- Effects of microplastics on terrestrial environments<br>- Health risks of microplastics in environments<br>- Project presentations by all students |
| **Literature** | - Microplastics in Terrestrial Environments (2021), Edited by Defu He and Yongming Luo<br>- Particulate Plastics in Terrestrial and Aquatic Environments (2020), Edited by Nanthi S. Bolan et al.<br>- Microplastic Pollutants (2017), by Christopher B. Crawford and Brian Quinn |

| Course L2751: Scientific Communication and Methods | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Nima Shokri |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Introduction - course objectives, expectations and format<br><br>Analyzing the Audience, purpose and occasion<br><br>Constructing and delivering effective technical presentations<br><br>How to write an abstract<br><br>How to create a scientific poster<br><br>How to write a scientific paper<br><br>Developing competitive and persuasive research proposals<br><br>Individual project (report and presentation) related to soil, water and environmental research |
| **Literature** | • The Craft of Scientific Writing Fourth edition<br>Author: Michael Alley<br>Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9<br><br>• Supplemental materials and web links which will be available to registered students. |

## Module M1779: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC) (L2926) | Project-/problem-based Learning | 4 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Hydraulic Engineering<br>• Hydromechanics, Hydraulics<br>• Fundamentals of Coastal Engineering, Coastal- and Flood Protection |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Climate and Climate Change<br>• General Impacts of Climate Change on Wind Regime and Water Cycle<br>• Consequences of Climate Change for Coastal Processes<br>• Coastal Protection in Taiwan and Germany<br>• Fundamentals of Climate Adaptation<br>• Nature-based Solutions (NBS) for Coastal Protection |
| *Skills* | • Critical thinking: analysis of processes and relations, assessment of needs for action<br>• Creative thinking: development of adaptation strategies and adaptation measures<br>• Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods<br>• Consideration of complex tasks |
| **Personal Competence** | |
| *Social Competence* | • Working in heterogenous groups<br>• Working in international groups<br>• Working with different scientific / non-scientific disciplines<br>• Self reflection |
| *Autonomy* | • Application oriented use of knowledge and skills<br>• Autonomous work on complex tasks |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Preparation of a written report on a complex task with a presentation and subsequent discussion. The work on the complex task happens in the course of the lecture. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory |

| Course L2926: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC) | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Climate and Climate Change<br>• General Impacts of Climate Change on Wind Regime and Water Cycle<br>• Consequences of Climate Change for Coastal Processes<br>• Coastal Protection in Taiwan and Germany<br>• Fundamentals of Climate Adaptation<br>• Nature-Based Solutions (NBS) for Coastal Protection |
| **Literature** | • Materials provided on eLearning Platform (HOOU Platform)<br>• Depending on the main topics of the course in the respective year, the literature ( recent papers) will be provided in the course-material or via StudIP. |

## Module M1980: Field measurements for environmental studies

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Field measurements for environmental studies: Application (L3231) | Project-/problem-based Learning | 3 | 4 |
| Field measurements for environmental studies: Theory (L3230) | Lecture | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Nima Shokri |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence**<br>*Knowledge*<br>*Skills*<br>**Personal Competence**<br>*Social Competence*<br>*Autonomy* | |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Report & Präsentation |
| **Assignment for the Following Curricula** | Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory |

### Course L3231: Field measurements for environmental studies: Application

| | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Dr. Milad Aminzadeh |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | |

### Course L3230: Field measurements for environmental studies: Theory

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Nima Shokri |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | |

# Specialization Water Quality and Water Engineering

## Module M0874: Wastewater Systems

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Biological Wastewater Treatment (L0517) | Lecture | 2 | 2 |
| Biological Wastewater Treatment (L3122) | Recitation Section (large) | 1 | 1 |
| Advanced Wastewater Treatment (L0357) | Lecture | 2 | 2 |
| Advanced Wastewater Treatment (L0358) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf Otterpohl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Knowledge of wastewater management and the key processes involved in wastewater treatment. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to outline key areas of the full range of treatment systems in waste water management, as well as their mutual dependence for sustainable water protection. They can describe relevant economic, environmental and social factors. |
| *Skills* | Students are able to pre-design and explain the available wastewater treatment processes and the scope of their application in municipal and for some industrial treatment plants. |
| **Personal Competence** | |
| *Social Competence* | Social skills are not targeted in this module. |
| *Autonomy* | Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Compulsory |

### Course L0517: Biological Wastewater Treatment

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Joachim Behrendt |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | Charaterisation of Wastewater<br>Metobolism of Microorganisms<br>Kinetic of mirobiotic processes<br>Calculation of bioreactor for wastewater treatment<br>Concepts of Wastewater treatment<br>Design of WWTP<br>Excursion to a WWTP<br>Biofilms<br>Biofim Reactors<br>Anaerobic Wastewater and sldge treatment<br>resources oriented sanitation technology<br>Future challenges of wastewater treatment |

| | |
|---|---|
| **Literature** | **Gujer, Willi**<br>Siedlungswasserwirtschaft : mit 84 Tabellen<br>ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?id=2842122&prov=M&dok_var=1&dok_ext=htm<br>Berlin [u.a.] : Springer, 2007<br>TUB_HH_Katalog<br>**Henze, Mogens**<br>Wastewater treatment : biological and chemical processes<br>ISBN: 3540422285 (Pp.)<br>Berlin [u.a.] : Springer, 2002<br>TUB_HH_Katalog<br>**Imhoff, Karl** (Imhoff, Klaus R.;)<br>Taschenbuch der Stadtentwässerung : mit 10 Tafeln<br>ISBN: 3486263331 ((Gb.))<br>München [u.a.] : Oldenbourg, 1999<br>TUB_HH_Katalog<br>**Lange, Jörg** (Otterpohl, Ralf; Steger-Hartmann, Thomas;)<br>Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft<br>ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334<br>Donaueschingen-Pfohren : Mall-Beton-Verl., 2000<br>TUB_HH_Katalog<br>**Mudrack, Klaus** (Kunst, Sabine;)<br>Biologie der Abwasserreinigung : 18 Tabellen<br>ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903<br>Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003<br>TUB_HH_Katalog<br>**Tchobanoglous, George** (Metcalf & Eddy, Inc., ;)<br>Wastewater engineering : treatment and reuse<br>ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk))<br>Boston [u.a.] : McGraw-Hill, 2003<br>TUB_HH_Katalog<br>**Henze, Mogens**<br>Activated sludge models ASM1, ASM2, ASM2d and ASM3<br>ISBN: 1900222248<br>London : IWA Publ., 2002<br>TUB_HH_Katalog<br>**Kunz, Peter**<br>Umwelt-Bioverfahrenstechnik<br>Vieweg, 1992<br>**Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt** (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, ;)<br>Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe aus der Abwasserbehandlung, Kleinkläranlagen<br>ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL: http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf<br>Weimar : Universitätsverl, 2006<br>TUB_HH_Katalog<br>**Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall**<br>DWA-Regelwerk<br>Hennef : DWA, 2004<br>TUB_HH_Katalog<br>**Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;)<br>Fundamentals of biological wastewater treatment<br>ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm<br>Weinheim : WILEY-VCH, 2007<br>TUB_HH_Katalog |

| **Course L3122: Biological Wastewater Treatment** | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Joachim Behrendt |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0357: Advanced Wastewater Treatment | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Joachim Behrendt |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Survey on advanced wastewater treatment<br>reuse of reclaimed municipal wastewater<br>Precipitation<br>Flocculation<br>Depth filtration<br>Membrane Processes<br>Activated carbon adsorption<br>Ozonation<br>"Advanced Oxidation Processes"<br>Disinfection |
| **Literature** | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003<br>Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987<br>Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007<br>Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006<br>Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003 |

| Course L0358: Advanced Wastewater Treatment | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Joachim Behrendt |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Aggregate organic compounds (sum parameters)<br>Industrial wastewater<br>Processes for industrial wastewater treatment<br>Precipitation<br>Flocculation<br>Activated carbon adsorption<br>Recalcitrant organic compounds |
| **Literature** | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003<br>Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987<br>Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007<br>Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006<br>Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003 |

## Module M1724: Smart Monitoring

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Smart Monitoring (L2762) | Integrated Lecture | 2 | 2 |
| Smart Monitoring (L2763) | Recitation Section (small) | 2 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Kay Smarsly |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge or interest in object-oriented modeling, programming, and sensor technologies are helpful. Interest in modern research and teaching areas, such as Internet of Things, Industry 4.0 and cyber-physical systems, as well as the will to deepen skills of scientific working, are required. Basic knowledge in scientific writing and good English skills. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence**<br>*Knowledge* | The students will become familiar with the principles and practices of smart monitoring. The students will be able to design decentralized smart systems to be applied for continuous (remote) monitoring of systems in the built and in the natural environment. In addition, the students will learn to design and to implement intelligent sensor systems using state-of-the-art data analysis techniques, modern software design concepts, and embedded computing methodologies. Besides lectures, project work is also part of this module, which will be conducted throughout the semester and will contribute to the grade. In small groups, the students will design smart monitoring systems that integrate a number of “intelligent” sensors to be implemented by the students. Specific focus will be put on the application of machine learning techniques. The smart monitoring systems will be mounted on real-world (built or natural) systems, such as bridges or slopes, or on scaled lab structures for validation purposes. The outcome of every group will be documented in a paper. All students of this module will “automatically” participate with their smart monitoring system in the annual "Smart Monitoring" competition. The written papers and oral examinations form the final grades. The module will be taught in English. Limited enrollment. |
| *Skills*<br>**Personal Competence**<br>*Social Competence*<br>*Autonomy* | |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | 10 pages of work with 15-minute oral presentation |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>Mechatronics: Technical Complementary Course: Elective Compulsory<br>Mechatronics: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory |

### Course L2762: Smart Monitoring

| | |
|---|---|
| **Typ** | Integrated Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kay Smarsly |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | In this course, principles of smart monitoring will be taught, focusing on modern concepts of data acquisition, data storage, and data analysis. Also, fundamentals of intelligent sensors and embedded computing will be illuminated. Autonomous software and decentralized data processing are further crucial parts of the course, including concepts of the Internet of Things, Industry 4.0 and cyber-physical systems. Furthermore, measuring principles, data acquisition systems, data management and data analysis algorithms will be discussed. Besides the theoretical background, numerous practical examples will be shown to demonstrate how smart monitoring may advantageously be used for assessing the condition of systems in the built or natural environment. |
| **Literature** | |

| Course L2763: Smart Monitoring | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kay Smarsly |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | The contents of the exercises are based on the lecture contents. In addition to the exercises, project work will be conducted throughout the semester, which will consume the majority of the workload. As part of the project work, students will design smart monitoring systems that will be tested in the laboratory or in the field. As mentioned in the module description, the students will participate in the “Smart Monitoring” competition, hosted annually by the Institute of Digital and Autonomous Construction. Students are encouraged to contribute their own ideas. The tools required to implement the smart monitoring systems will be taught in the group exercises as well as through external sources, such as video tutorials and literature. |
| **Literature** | |

## Module M0858: Coastal Hydraulic Engineering I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Basics of Coastal Engineering (L0807) | Lecture | 3 | 4 |
| Basics of Coastal Engineering (L1413) | Project-/problem-based Learning | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of hydraulic engineering, hydrology and hydromechanics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to define and explain the basic concepts of coastal engineering and port engineering. They are able to apply the concepts to selected practical problems of coastal engineering. Students can define and determine the basics for design and dimensioning of coastal engineering constructions. |
| *Skills* | The students are capable to apply basic design approaches to selected and pre-defined design tasks in coastal engineering. |
| **Personal Competence** | |
| *Social Competence* | The students are able to deploy their gained knowledge in applied problems such as the design of coastal protection structures. Additionaly, they will be able to work in team with engineers of other disciplines, for instance designing of coastal breakwaters. |
| *Autonomy* | The students will be able to independently extend their knowledge and applyit to new problems. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | The duration of the examination is 2 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Coastal Engineering: Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Compulsory<br>Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory |

| Course L0807: Basics of Coastal Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Basics of planning and design<br>  ◦ Water levels<br>  ◦ Currents<br>  ◦ Waves<br>  ◦ Ice<br>• Planning and Design in Coastal Engineering<br>  ◦ Functional and constructional design<br>  ◦ Determination of design parameters<br>  ◦ Design-approaches<br>  ▪ Filter<br>  ▪ Rubble mound constructions<br>  ▪ Piles<br>  ▪ Vertical constructions |
| **Literature** | Coastal Engineering Manual, CEM<br><br>Vorlesungsumdruck |

| Course L1413: Basics of Coastal Engineering | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1898: Study Work Water Quality and Water Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|

| | |
|---|---|
| **Module Responsible** | Dozenten des Studiengangs |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to demonstrate their detailed knowledge in a field of water and environmental engineering. The students are qualified to project water technology and environmental protection-oriented projects and to independently define research tasks for the theoretical and experimental investigation of environmental problems and water management issues. They are able to give examples of the state of development and application and to discuss these critically, taking into account current problems and framework conditions in science and society. The students are able to independently define a solution strategy for a basic, application-oriented or practical problem from the field of water and environmental engineering and to outline individual solution approaches. They can proceed in a theory-oriented manner and include current safety, ecological, ethical and economic aspects according to the state of the art in science and related social discussions.<br><br>They can use the scientific working techniques they have chosen for their own project work, they can present them in detail and critically discuss them. |
| *Skills* | Students are able to independently select methodological approaches for project work and justify this selection in terms of content. They can explain how they relate approaches or methods to the specific field of application in a solution-oriented manner and adapt them to the application context. They can outline the main points and further developments that go beyond the project. |
| **Personal Competence** | |
| *Social Competence* | Students are able to prepare the relevance and cut of their project task, the work steps and sub-problems for discussion and debate in larger groups, guide the discussions and give feedback to colleagues on their projects. |
| *Autonomy* | The students are able to independently plan and document the work steps and processes necessary to complete the coursework, taking into account specified deadlines. This includes being able to obtain current scientific information in a goal-oriented manner. Furthermore, they are able to obtain feedback on the progress of work from experts in the field in order to achieve high-quality work results based on the state of the art in science and technology. |
| **Workload in Hours** | Independent Study Time 360, Study Time in Lecture 0 |
| **Credit points** | 12 |
| **Course achievement** | None |
| **Examination** | Study work |
| **Examination duration and scale** | depending on task |
| **Assignment for the Following Curricula** | Environmental Engineering: Specialisation Water Quality and Water Engineering: Compulsory |

## Module M0949: Rural Development and Resources Oriented Sanitation for different Climate Zones

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Rural Development and Resources Oriented Sanitation for different Climate Zones (L0942) | Seminar | 2 | 3 |
| Rural Development and Resources Oriented Sanitation for different Climate Zones (L0941) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf Otterpohl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of the global situation with rising poverty, soil degradation, lack of water resources and sanitation |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can describe resources oriented wastewater systems mainly based on source control in detail. They can comment on techniques designed for reuse of water, nutrients and soil conditioners.<br><br>Students are able to discuss a wide range of proven approaches in Rural Development from and for many regions of the world. |
| *Skills* | Students are able to design low-tech/low-cost sanitation, rural water supply, rainwater harvesting systems, measures for the rehabilitation of top soil quality combined with food and water security. Students can consult on the basics of soil building through “Holisitc Planned Grazing” as developed by Allan Savory. |
| **Personal Competence** | |
| *Social Competence* | The students are able to develop a specific topic in a team and to work out milestones according to a given plan. |
| *Autonomy* | Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information will be provided at the beginning of the smester. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

### Course L0942: Rural Development and Resources Oriented Sanitation for different Climate Zones

| | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Central part of this module is a group work on a subtopic of the lectures. The focus of these projects will be based on an interview with a target audience, practitioners or scientists.<br>• The group work is divided into several Milestones and Assignments. The outcome will be presented in a final presentation at the end of the semester. |
| **Literature** | • J. Lange, R. Otterpohl 2000: Abwasser - Handbuch zu einer zukunftsfähigen Abwasserwirtschaft. Mallbeton Verlag (TUHH Bibliothek)<br>• Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download)<br>• Schober, Sabine: WTO/TUHH Award winning Terra Preta Toilet Design: http://youtu.be/w_R09cYq6ys |

| Course L0941: Rural Development and Resources Oriented Sanitation for different Climate Zones | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Living Soil - THE key element of Rural Development<br>• Participatory Approaches<br>• Rainwater Harvesting<br>• Ecological Sanitation Principles and practical examples<br>• Permaculture Principles of Rural Development<br>• Performance and Resilience of Organic Small Farms<br>• Going Further: The TUHH Toolbox for Rural Development<br>• EMAS Technologies, Low cost drinking water supply |
| **Literature** | • Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk<br>• Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press |

## Module M0802: Membrane Technology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Membrane Technology (L0399) | Lecture | 2 | 3 |
| Membrane Technology (L0400) | Recitation Section (small) | 1 | 2 |
| Membrane Technology (L0401) | Practical Course | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Mathias Ernst |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of water chemistry. Knowledge of the core processes involved in water, gas and steam treatment |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will be able to rank the technical applications of industrially important membrane processes. They will be able to explain the different driving forces behind existing membrane separation processes. Students will be able to name materials used in membrane filtration and their advantages and disadvantages. Students will be able to explain the key differences in the use of membranes in water, other liquid media, gases and in liquid/gas mixtures. |
| *Skills* | Students will be able to prepare mathematical equations for material transport in porous and solution-diffusion membranes and calculate key parameters in the membrane separation process. They will be able to handle technical membrane processes using available boundary data and provide recommendations for the sequence of different treatment processes. Through their own experiments, students will be able to classify the separation efficiency, filtration characteristics and application of different membrane materials. Students will be able to characterise the formation of the fouling layer in different waters and apply technical measures to control this. |
| **Personal Competence** | |
| *Social Competence* | Students will be able to work in diverse teams on tasks in the field of membrane technology. They will be able to make decisions within their group on laboratory experiments to be undertaken jointly and present these to others. |
| *Autonomy* | Students will be in a position to solve homework on the topic of membrane technology independently. They will be capable of finding creative solutions to technical questions. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Technical Complementary Course: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

| Course L0399: Membrane Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Mathias Ernst |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | The lecture on membrane technology supply provides students with a broad understanding of existing membrane treatment processes, encompassing pressure driven membrane processes, membrane application in electrodialyis, pervaporation as well as membrane distillation. The lectures main focus is the industrial production of drinking water like particle separation or desalination; however gas separation processes as well as specific wastewater oriented applications such as membrane bioreactor systems will be discussed as well.<br><br>Initially, basics in low pressure and high pressure membrane applications are presented (microfiltration, ultrafiltration, nanofiltration, reverse osmosis). Students learn about essential water quality parameter, transport equations and key parameter for pore membrane as well as solution diffusion membrane systems. The lecture sets a specific focus on fouling and scaling issues and provides knowledge on methods how to tackle with these phenomena in real water treatment application. A further part of the lecture deals with the character and manufacturing of different membrane materials and the characterization of membrane material by simple methods and advanced analysis.<br><br>The functions, advantages and drawbacks of different membrane housings and modules are explained. Students learn how an industrial membrane application is designed in the succession of treatment steps like pre-treatment, water conditioning, membrane integration and post-treatment of water. Besides theory, the students will be provided with knowledge on membrane demo-site examples and insights in industrial practice. |
| **Literature** | • T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage), Springer-Verlag, Berlin 2004.<br>• Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands<br>• Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley & Sons, Ltd., 2004 |

| Course L0400: Membrane Technology | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Mathias Ernst |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0401: Membrane Technology | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Mathias Ernst |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0822: Process Modeling in Water Technology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Process Modelling of Wastewater Treatment (L0522) | Project-/problem-based Learning | 2 | 3 |
| Process Modeling in Drinking Water Treatment (L0314) | Project-/problem-based Learning | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Dr. Klaus Johannsen |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Knowledge of the most important processes in drinking water and waste water treatment. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to explain selected processes of drinking water and waste water treatment in detail. They are able to explain basics as well as possibilities and limitations of dynamic modeling. |
| *Skills* | Students are able to use the most important features Modelica offers. They are able to transpose selected processes in drinking water and waste water treatment into a mathematical model in Modelica with respect to equilibrium, kinetics and mass balances. They are able to set up and apply models and assess their possibilities and limitations. |
| **Personal Competence** | |
| *Social Competence* | Students are able to solve problems and document solutions in a group with members of different technical background. They are able to give appropriate feedback and can work constructively with feedback concerning their work. |
| *Autonomy* | Students are able to define a problem, gain the required knowledge and set up a model. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Oral exam |
| **Examination duration and scale** | 30 min |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Chemical and Bioprocess Engineering: Technical Complementary Course: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

| Course L0522: Process Modelling of Wastewater Treatment | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Joachim Behrendt |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | Mass and energy balances<br><br>Tracer modelling<br><br>Activated Sludge Model<br><br>Wastewater Treatment Plant Modelling (continously and SBR)<br><br>Sludge Treatment (ADM, aerobic autothermal)<br><br>Biofilm Modelling |
| **Literature** | **Henze, Mogens** (Seminar on Activated Sludge Modelling, ; Kollekolle Seminar on Activated Sludge Modelling, ;)<br>Activated sludge modelling : processes in theory and practice ; selected proceedings of the 5th Kollekolle Seminar on Activated Sludge Modelling, held in Kollekolle, Denmark, 10 - 12 September 2001<br>ISBN: 1843394146<br>[London] : IWA Publ., 2002<br>TUB_HH_Katalog<br>**Henze, Mogens**<br>Activated sludge models ASM1, ASM2, ASM2d and ASM3<br>ISBN: 1900222248<br>London : IWA Publ., 2002<br>TUB_HH_Katalog<br>**Henze, Mogens**<br>Wastewater treatment : biological and chemical processes<br>ISBN: 3540422285 (Pp.)<br>Berlin [u.a.] : Springer, 2002<br>TUB_HH_Katalog<br>**Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;)<br>Fundamentals of biological wastewater treatment<br>ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm<br>Weinheim : WILEY-VCH, 2007<br>TUB_HH_Katalog |

| Course L0314: Process Modeling in Drinking Water Treatment | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Klaus Johannsen |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | In this course selected drinking water treatment processes (e.g. aeration or activated carbon adsorption) are modeled dynamically using the programming language Modelica, that is increasingly used in industry. In this course OpenModelica is used, an free access frontend of the programming language Modelica.<br><br>In the beginning of the course the use of OpenModelica is explainded by means of simple examples. Together required elements and structure of the model are developed. The implementation in OpenModelica and the application of the model is done individually or in groups respectively. Students get feedback and can gain extra points for the exam. |
| **Literature** | **OpenModelica:** https://openmodelica.org/index.php/download/download-windows<br><br>**OpenModelica - Modelica Tutorial:** https://openmodelica.org/index.php/useresresources/userdocumentation<br><br>**OpenModelica - Users Guide:** https://openmodelica.org/index.php/useresresources/userdocumentation<br><br>**Peter Fritzson:** Principles of Object-Oriented Modeling and Simulation with Modelica 2.1,Wiley-IEEE Press, ISBN 0-471-471631.<br><br>**MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005.<br><br>**Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996.<br><br>**DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004. |

## Module M0859: Coastal Hydraulic Engineering II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Coastal- and Flood Protection (L0808) | Lecture | 2 | 3 |
| Coastal- and Flood Protection (L1415) | Project-/problem-based Learning | 1 | 1 |
| Maintenance and Defence of Flood Protection Structures (L1411) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Coastal Engineering I |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students have the capability to define and explain in detail the important aspects of erosion protection and flood protection and are able to apply the aspects to practical coastal protection problems. They are able to design and dimension important coastal protection measures from the functional and from the constructional point of view. |
| *Skills* | The students are able to select design approaches for the functional and constructional design of erosion and flood protection measures and apply these approaches to practical design tasks. |
| **Personal Competence** | |
| *Social Competence* | The students are able to deploy their gained knowledge in applied problems such as the functional and constructive design of coastal and flood protection structures. Additionaly, they will be able to work in team with engineers of other disciplines. |
| *Autonomy* | The students will be able to independently extend their knowledge and apply it to new problems. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | The duration of the examination is 130 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Coastal Engineering: Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory |

| Course L0808: Coastal- and Flood Protection | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Protection of sandy coasts<br>• Sediment transport<br>• Morphology<br>• Technical solution for the protection of sandy coasts<br>  ◦ Construction in direction of the coast<br>  ◦ Constructions perpendicular to the coast<br>  ◦ Other Concepst<br>• Calculation approaches and numerical models<br>Flood Protection<br>• Classification of constructions / measures<br>• Dikes<br>• Dunes<br>• Foreland - constructions<br>• Flood-Protection Walls<br>• Drainage of the hinterland |
| **Literature** | Vorlesungsumdruck<br>Coastal Engineering Manual CEM |

| Course L1415: Coastal- and Flood Protection | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1411: Maintenance and Defence of Flood Protection Structures | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Olaf Müller |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Dike protection<br>• Maintennance of flood protection measures |
| **Literature** | Vorlesungsumdruck |

## Module M0581: Water Protection

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Water Protection and Wastewater Management (L0226) | Lecture | 3 | 3 |
| Water Protection and Wastewater Management (L2008) | Project Seminar | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf Otterpohl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Basic knowledge in water management;<br>• Good knowledge in urban drainage;<br>• Good knowledge of wastewater treatment techniques;<br>• Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties; |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can describe the basic principles of the regulatory framework related to the international and European water sector. They can explain limnological processes, substance cycles and water morphology in detail. They are able to assess complex problems related to water protection, such as ecosystem service and wastewater treatment with a special focus on innovative solutions, remediation measures as well as conceptual approaches. |
| *Skills* | Students can accurately assess current problems and situations in a country-specific or local context. They can suggest concrete actions to contribute to the planning of tomorrow's urban water cycle. Furthermore, they can suggest appropriate technical, administrative and legislative solutions to solve these problems. |
| **Personal Competence** | |
| *Social Competence* | The students can work together in international groups. |
| *Autonomy* | Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Presentation |
| **Examination duration and scale** | Term paper plus presentation |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Compulsory |

| Course L0226: Water Protection and Wastewater Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | The lecture focusses on:<br>• Regulatory Framework (e.g. WFD)<br>• Main instruments for the water management and protection<br>• In depth knowledge of relevant measures of water pollution control<br>• Urban drainage, treatment options in different regions on the world<br>• Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration<br>• Case Studies and Field Trips |
| **Literature** | The literature listed below is available in the library of the TUHH.<br>• Water and wastewater technology Hammer, M. J. 1., & . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International.<br>• Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill.<br>• Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ. |

| Course L2008: Water Protection and Wastewater Management | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

# Thesis

## Module M1801: Master thesis (dual study program)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|

| | |
|---|---|
| **Module Responsible** | Professoren der TUHH |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students ...<br>• ... use the specialised knowledge (facts, theories and methods) from their field of study and the acquired professional knowledge confidently to deal with technical and practical professional issues.<br>• ... can explain the relevant approaches and terminologies in depth in one or more of their subject's specialist areas, describe current developments and take a critical stance.<br>• ... formulate their own research assignment to tackle a professional problem and contextualise it within their subject area. They ascertain the current state of research and critically assess it. |
| *Skills* | Dual students ...<br>• ... can select suitable methods for the respective subject-related professional problem, apply them and develop them further as required.<br>• ... assess knowledge and methods acquired during their studies (including practical phases) and apply their expertise to complex and/or incompletely defined problems in a solution- and application-oriented manner.<br>• ... acquire new academic knowledge in their subject area and critically evaluate it. |
| **Personal Competence** | |
| *Social Competence* | Dual students ...<br>• ... can present a professional problem in the form of an academic question in a structured, comprehensible and factually correct manner, both in writing and orally, for a specialist audience and for professional stakeholders.<br>• ... answer questions as part of a professional discussion in an expert, appropriate manner. They represent their own points of view and assessments convincingly. |
| *Autonomy* | Dual students ...<br>• ... can structure their own project into work packages, work through them at an academic level and reflect on them with regard to feasible courses of action for professional practice.<br>• ... work in-depth in a partially unknown area within the discipline and acquire the information required to do so.<br>• ... apply the techniques of academic work comprehensively in their own research work when dealing with an operational problem and question. |
| **Workload in Hours** | Independent Study Time 900, Study Time in Lecture 0 |
| **Credit points** | 30 |
| **Course achievement** | None |
| **Examination** | Thesis |
| **Examination duration and scale** | According to General Regulations |
| **Assignment for the Following Curricula** | Civil Engineering: Thesis: Compulsory<br>Bioprocess Engineering: Thesis: Compulsory<br>Chemical and Bioprocess Engineering: Thesis: Compulsory<br>Chemical and Bioprocess Engineering: Thesis: Compulsory<br>Computer Science: Thesis: Compulsory<br>Data Science: Thesis: Compulsory<br>Electrical Engineering and Information Technology: Thesis: Compulsory<br>Electrical Engineering: Thesis: Compulsory<br>Energy Systems: Thesis: Compulsory<br>Environmental Engineering: Thesis: Compulsory<br>Aircraft Systems Engineering: Thesis: Compulsory<br>Computer Science in Engineering: Thesis: Compulsory<br>Information and Communication Systems: Thesis: Compulsory<br>International Management and Engineering: Thesis: Compulsory<br>Logistics, Infrastructure and Mobility: Thesis: Compulsory<br>Aeronautics: Thesis: Compulsory<br>Materials Science and Engineering: Thesis: Compulsory<br>Materials Science: Thesis: Compulsory<br>Mechanical Engineering and Management: Thesis: Compulsory<br>Mechatronics: Thesis: Compulsory |

| | |
|---|---|
| | Biomedical Engineering: Thesis: Compulsory<br>Microelectronics and Microsystems: Thesis: Compulsory<br>Product Development, Materials and Production: Thesis: Compulsory<br>Renewable Energies: Thesis: Compulsory<br>Naval Architecture and Ocean Engineering: Thesis: Compulsory<br>Theoretical Mechanical Engineering: Thesis: Compulsory<br>Process Engineering: Thesis: Compulsory<br>Water and Environmental Engineering: Thesis: Compulsory |