Module Manual

Master of Science (M.Sc.)

Environmental Engineering
Dual study program

Cohort: Winter Term 2023

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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. • Students are able to explain basic theories, categories, and models in selected special areas of business management. • Students are able to interrelate technical and management knowledge.
Skills	• Students are able to apply basic methods in selected areas of business management. • 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 Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory 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. In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation. Experiments ar e.g. Screening and particle size determination Fos/Tac AAS 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 2. biological basics 3. determination process specific material characterization 4. aerobic degradation (Composting, stabilization) 5. anaerobic degradation (Biogas production, fermentation) 6. Technical layout and process design 7. Flue gas treatment 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. 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. 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. 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 • Quantification of bacteria in drinking water • Identification of bacteria • Bacterial population analyses • Growth of bacteria and VBNC-state • Activity of bacteria in the environment • Biofilms in drinking water systems • Disinfection of drinking water and drinking water systems • Microbiological processes in drinking water treatment • Technical realization for optimized use of microbiological processes for drinking water production • 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. • 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. • 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 • Current UN World Water Development Reports • Water Security for Better Lives, OECD Studie 2013 • 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 • Data models, geographical coordinates, geo-referencing, map-views • Data mining and – analyses of geo-data • 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 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 - Analysis of nutrients in wastewater samples (different methods for nitrate analysis) - Alkalinity - TOC, COD - 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 Sampling in different environmental compartments, sample transportation, sample storage Sample preparation Photometry Wastewater analysis Introduction into chromatography Gas chromatography HPLC Mass spectrometry Optical emission spectrometry Atom absorption spectrometry Quality assurance in environmental analysis
Literature	Roger Reeve, Introduction to Environmental Analysis, John Wiley & Sons Ltd., 2002 (TUB: USD-728) Pradyot Patnaik, Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes, CRC Press, Boca Raton, 2010 (TUB: USD-716) Chunlong Zhang, Fundamentals of Environmental Sampling and Analysis, John Wiley & Sons Ltd., Hoboken, New Jersey, 2007 (TUB: USD-741) Miroslav Radojević, Vladimir N. Bashkin, Practical Environmental Analysis RSC Publ., Cambridge, 2006 (TUB: USD-720) 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) 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) K. Robards, P. R. Haddad, P. E. Jackson, Principles and Practice of Modern Chromatographic Methods, Academic Press G. Schwedt, Chromatographische Trennmethoden, Thieme Verlag H. M. McNair, J. M. Miller, Basic Gas Chromatography, Wiley W. Gottwald, GC für Anwender, VCH B. A. Bidlingmeyer, Practical HPLC Methodology and Applications, Wiley K. K. Unger, Handbuch der HPLC, GIT Verlag G. Aced, H. J. Möckel, Liquidchromatographie, VCH Charles B. Boss and Kenneth J. Fredeen, Concepts, Instrumentation and Techniques in Inductively Coupled Plasma Optical Emission Spectrometry Perkin-Elmer Corporation 1997, On-line available at: http://files.instrument.com.cn/bbs/upfile/2006291448.pdf Atomic absorption spectrometry: theory, design and applications, ed. by S. J. Haswell 1991 (TUB: 2727-5614) 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 • 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 ... ... can describe and classify selected classic and current theories, concepts and methods • related to project management and • change and transformation management ... and apply them to specific situations, processes and plans in a personal, professional context.
Skills	Dual students ... • ... 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. • ... 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 ... • ... can responsibly lead interdisciplinary teams within the framework of complex tasks and problems. • ... 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 ... • ... define, reflect and evaluate goals and measures for complex application-oriented projects and change processes. • ... shape their professional area of responsibility independently and sustainably. • ... 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 • Innovation management • Agile project management • Fundamentals of classic and agile methods • Hybrid use of classic and agile methods • Roles, perspectives and stakeholders throughout the project • Initiating and coordinating complex engineering projects • Principles of moderation, team management, team leadership, conflict management • Communication structures: in-house, cross-company • Public information policy • Promoting commitment and empowerment • Sharing experience with specialists and managers from the engineering sector • 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 • Models and methods of organisational design and development • Strategic orientation and change, and their short-, medium- and long-term consequences for individuals, organisations and society as a whole • Roles, perspectives and stakeholders in change processes • Initiating and coordinating change measures in engineering • Phase models of organisational change (Lewin, Kotter, etc.) • Change-oriented information policy and dealing with resistance and uncertainty • Promoting commitment and empowerment • Successfully handling change and transformation: personally, as an employee, as a manager (personal, professional, organisational) • Company-level and globally (systemic) • Sharing experience with specialists and managers from the engineering sector • 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 • 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 ... • ... 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. • ... have a critical understanding of the practical applications of their engineering subject.
Skills	Dual students ... • ... 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. • ... implement the university's application recommendations with regard to their current tasks. • ... develop solutions as well as procedures and approaches in their field of activity and area of responsibility.
Personal Competence	
Social Competence	Dual students ... • ... work responsibly in project teams within their working area and proactively deal with problems within their team. • ... represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders.
Autonomy	Dual students ... • ... define goals for their own learning and working processes as engineers. • ... reflect on learning and work processes in their area of responsibility. • ... 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 Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Aeronautics: Core Qualification: Compulsory Materials Science and Engineering: Core Qualification: Compulsory Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory Microelectronics and Microsystems: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Renewable Energies: Core Qualification: Compulsory

	Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory 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** • Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work • Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.) • Working independently in a team and on selected projects - across departments and, if applicable, across companies • Scheduling the current practical module with a clear correlation to work structures • Scheduling the examination phase/subsequent study semester **Operational knowledge and skills** • 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 • Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity • Systemic skills • Implementing the university's application recommendations (theory-practice transfer) in corresponding work and task areas across the company **Sharing/reflecting on learning** • Creating an e-portfolio • Importance of course contents (M.Sc.) when working as an engineer • Importance of development and innovation when working as an engineer
Literature	• Studierendenhandbuch • Betriebliche Dokumente • 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 Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 - 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 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	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 • Gas-water partitioning • Acid/base equilibria • Alkalinity and acidity • Precipitation/dissolution equilibria • Redox equilibria • Complex formation • 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, Centrifugation, Flotation, Filtration, Aerobic sludge stabilisation, Sludge Digestion, Sludge Disintegration, Sludge Dewatering, Natural Processes for Sludge Treatment, Nutrient Recovery from Sludge, Thermal Processes and Incineration.
Literature	**Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes** Sludge Treatment and Disposal ISBN 9781843391661 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.
	
	The course is structured as follows:
	
	• Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course
	• Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste
	• Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying
	• Thermo-chemical conversion of solid biofuels
	  ◦ Basics of thermo-chemical conversion
	  ◦ 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
	  ◦ Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels
	  ◦ 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
	• 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)
	• Bio-chemical conversion of biomass
	  ◦ Basics of bio-chemical conversion
	  ◦ 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
	  ◦ 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. Within the practical lab course the students discuss different technical-scientific tasks, both subject-specifically and interdisciplinary. They 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 - Versuchsskript

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 • 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 ... • ... 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. • ... have a critical understanding of the practical applications of their engineering subject.
Skills	Dual students ... • ... 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. • ... implement the university's application recommendations with regard to their current tasks. • ... 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 ... • ... work responsibly in cross-departmental and interdisciplinary project teams and proactively deal with problems within their team. • ... represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders and develop these further together.
Autonomy	Dual students ... • ... define goals for their own learning and working processes as engineers. • ... reflect on learning and work processes in their area of responsibility. • ... 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 Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Aeronautics: Core Qualification: Compulsory Materials Science and Engineering: Core Qualification: Compulsory Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory Microelectronics and Microsystems: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory

	Renewable Energies: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory 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** • Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work • Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.) • Taking personal responsibility within a team and on selected projects - across departments and, if applicable, across companies • Scheduling the current practical module with a clear correlation to work structures • Scheduling the examination phase/subsequent study semester **Operational knowledge and skills** • 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 • Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity • Systemic skills • Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company **Sharing/reflecting on learning** • Updating their e-portfolio • Importance of course contents (M.Sc.) when working as an engineer • Importance of development and innovation when working as an engineer
Literature	• Studierendenhandbuch • Betriebliche Dokumente • 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, Module:Organic Chemistry, 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 Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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. 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 Lehrbuchsammlung der TUB, Signatur USH-305 2) **Solid Waste Technology and Management.** Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332 3) **Natural attenuation of fuels and chlorinated solvents in the subsurface.** Todd H. Wiedemeier(Ed.), ISBN: 0471197491 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 Leiden [u.a.] Balkema 2005 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 Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 • Keynote lecture and video • The limits of Urbanization / Green Cities • The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities • Global Ecovillage Network: Upsides and Downsides around the World • Visit of an Ecovillage • Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competion • TUHH Rural Development Toolbox • Integrated New Town Development • Participants workshop: Design of New Towns: Northern, Arid and Tropical cases • Outreach: Participants campaign • 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 • http://youtu.be/9hmkgn0nBgk (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation) • 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 • Water & Soil: Water availability as a consequence of healthy soils • Water and it's utilization, Integrated Urban Water Management • Water & Energy, lecture and panel discussion pro and con for a specific big dam project • Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation • Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches • Why are there excreta in water? Public Health, Awareness Campaigns • Rehearsal session, Q&A
Literature	• Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press • Liu, John D.: http://eempc.org/hope-in-a-changing_climate/ (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda) • 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 • Knowledge on measures for climate protection • 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). 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 Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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) 2) WHO (1999): Guidelines for Community Noise 3) Environmental Noise Directive 2002/49/EG 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 Main topics are: • Central vs. Decentral Wastewater Treatment. • Compaction of Cities. • Car Free Cities. • Multifunctional Places in Cities. • 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 Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory 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 • Processes affecting tht flow • Examples and applications of numerical models • Procedure of numerical modelling • Model concept Basic equations of hydrodynamics • Saint-Venant equations • Euler Equations • Navier-Stokes equations • Reynolds-averaged Navier-Stokes equations • Shallow water equations Solving schemes • Numerical discretization • Solution algorithms • Convergence
Literature	Vorlesungsskript Literaturempfehlungen Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt). Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series). 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). 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). 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). 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. IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92. Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology. Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83). 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). 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 • Engineering - biological measures for the stabilization of rivers • Risk management in flood protection • Design techniques in technical flood protection • 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 Comfortable with math and physics, critical thinking, creative problem solving 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 Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 - Soil Physics, Sixth Edition, by William A. Jury and Robert Horton - Physical Hydrology, Second Edition, by S. Lawrence Dingman - 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 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 Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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: • Hydrological cycle • Data acquisition • Data analyses and statistical assessment • Statistics of extremes • Regionalization methods for hydrological values • Rainfall-run-off modelling on the basis of a unit hydrograph conceps • 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) http://kalypso.bjoernsen.de/ 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 • 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 ... • ... 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. • ... have a critical understanding of the practical applications of their engineering subject, as well as related fields when implementing innovations.
Skills	Dual students ... • ... 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. • ... implement the university's application recommendations with regard to their current tasks. • ... 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). • ... 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 ... • ... work responsibly in cross-departmental and interdisciplinary project teams and proactively deal with problems within their team. • ... can promote the professional development of others in a targeted manner. • ... 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 ... • ... reflect on learning and work processes in their area of responsibility. • ... define goals for new application-oriented tasks, projects and innovation plans while reflecting on potential effects on the company and the public. • ... 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 Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Compulsory Environmental Engineering: Core Qualification: Compulsory Aircraft Systems Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Aeronautics: Core Qualification: Compulsory Materials Science and Engineering: Core Qualification: Compulsory

	Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory Microelectronics and Microsystems: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Renewable Energies: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory 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** • Assigning a future professional field of activity as an engineer (M.Sc.) and associated fields of work • Extending responsibilities and authorisation of the dual student within the company up to the intended first assignment after completing their studies • Working responsibly in a team; project responsibility within own area - as well as across divisions and companies if necessary • Scheduling the final practical module with a clear correlation to work structures • Internal agreement on a potential topic or innovation project for the Master’s dissertation • Planning the Master’s dissertation within the company in cooperation with TU Hamburg • Scheduling the examination phase/subsequent study semester **Operational knowledge and skills** • 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 • Specialising in one field of work (final dissertation) • Systemic skills • Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company **Sharing/reflecting on learning** • E-portfolio • Relevance of study content and personal specialisation when working as an engineer • Relevance of research and innovation when working as an engineer
Literature	• Studierendenhandbuch • betriebliche Dokumente • 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 Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory 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) • Use and demand of metals and minerals in industry and society • collection systems and concepts • quota and efficiency • Advanced sorting technologies • mechanical pretreatment • advanced treatment • Chemical analysis of Critical Materials in post-consumer products • 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) • Use and demand of metals and minerals in industry and society • collection systems and concepts • quota and efficiency • Advanced sorting technologies • mechanical pretreatment • advanced treatment • Chemical analysis of Critical Materials in post-consumer products • 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
	• Introduction into the " Waste to Energy " consisting of:
	  ◦ Thermal Process (incinerator , RDF combustion)
	  ◦ Biological processes (Wet-/Dryfermentation)
	  ◦ technology , energy , emissions, approval , etc.
	• Group work
	  ◦ design of systems/plants for energy recovery from waste
	  ◦ The following points are to be processed :
	    ▪ Input: waste (fraction collection and transportation, current quantity , material flows , possible amount of development)
	    ▪ Plant (design, process diagram , technology, energy production)
	    ▪ Output (energy quantity / type , by-products)
	    ▪ Costs and revenues
	    ▪ Climate and resource protection (CO2 balance , substitution of primary raw materials / fossil fuels)
	    ▪ Location and approval (infrastructure , expiration authorization procedure)
	    ▪ Focus at the whole concept (advantages, disadvantages , risks and opportunities , discussion)
	• Grading: No Exam , but presentation of the results of the working group

Literature	**Literatur:** Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010 Powerpoint-Folien in Stud IP **Literature:** Introduction to Waste Management; Kranert Martin , Klaus Cord - Landwehr (Ed.), Vieweg + Teubner Verlag , 2010 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. 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. • Introduction to Applied Optimization • Formulation of optimization problems • Linear Optimization • Nonlinear Optimization • Mixed-integer (non)linear optimization • Multi-objective optimization • 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: •develop solutions in heterogeneous small groups
Autonomy	Students are capable of: •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 Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory 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. - Introduction to Applied Optimization - Formulation of optimization problems - Linear Optimization - Nonlinear Optimization - Mixed-integer (non)linear optimization - Multi-objective optimization - Global optimization
Literature	Weicker, K., Evolutionäre Algortihmen, Springer, 2015 Edgar, T. F., Himmelblau D. M., Lasdon, L. S., Optimization of Chemical Processes, McGraw Hill, 2001 Biegler, L. Nonlinear Programming - Concepts, Algorithms, and Applications to Chemical Processes, 2010 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 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; 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 Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory 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. The lecture gives an overview on biorefinery technology and shall contribute to promotion of international biorefinery developments. Lectures: • What is a biorefinery: Overview on basic organic substrates and processes which lead to material and energy products • The way from a fossil based to a biobased economy in the 21st century • The worlds most advanced biorefinery • Presentation of various biorefinery systems and their products (e.g. lignocellulose biorefinery, green biorefinery, whole plant biorefinery, civilization biorefinery) • Example projects (e.g. combination of anaerobic digestion and composting in practice; demonstration project in Hamburgs city quarter Jenfelder Au) 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). 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 Powerpoint-Präsentations / selected Publications / further recommendations depending on the actual developments 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. 2.) Self-dependent recherches to the topic. 3.) Preparation of a written elaboration. 4.) Presentation of the results in the group.
Literature	Vom Thema abhängig. Eigene Recherchen nötig. 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. 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: *Lectures on:* • Bioresource generation and utilization including lost potentials today • Basic biological, mechanical, physico-chemical and logistical processes • The conflict of material vs. energy generation from wood / waste wood • The basics of pulp & paper production including waste paper recycling • The Pros and Cons from biogas and compost production *Special lectures by invited guests from research and practice:* • Pathways of waste organics on the example of Hamburg`s City Cleaning Company • Utilization options of landscaping materials on the example of grass • Increase of process efficiency of anaerobic digestions • Decision support tools on the example of an municipality in Indonesia *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: • basics in safety and reliability of technical facilities • risk assessment and reliability analysis methods • Circularity of material • Identification and evaluation of material flows • energy production and supply • 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 Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Management and Controlling: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory 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. The following list shows examples: • Production and use of biochar • Energy production with algae • Environmentally friendly product design • Clean development mechanisms • Democracy and energy • Alternative mobility
Literature	Wird in der Veranstaltung bekannt gegeben.

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. 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: • Module-spanning solutions for the design and presentation of fuel production processes resp. the fuel provision chains • Comprehensive analysis of various fuel production options in technical, ecological and economic terms 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**: Yes; **Bonus**: 20 %; **Form**: Written elaboration; **Description**: 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 Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Energy and Bioprocess Technology: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory 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) • 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) • Origin, production and use of these fuels
Literature	• Babu, V.: Biofuels Production. Beverly, Mass: Scrivener [u.a.], 2013 • Olsson, L.: Biofuels. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg, 2007 • William, L. L.: Distillation Design and Control Using Aspen Simulation; ISBN-10: 0-471-77888-5 • Perry, R.; Green, R.: Perry's Chemical Engineers' Handbook, 8th Edition, McGraw Hill Professional, 20 • Sinnot, R. K.: Chemical Engineering Design, Elsevier, 2014 • 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 • Design and simulation of sub-processes of production processes in Aspen Plus ® • Ecological and economic analysis of fuel supply paths • Classification of case studies into applicable regulations
Literature	• Skriptum zur Vorlesung • 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: • Consideration of the environmental impact of the various alternative fuels • Economic consideration of the different alternative fuels • Regulatory framework for alternative fuels • Certification of alternative fuels • 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 • Richtlinie (EU) 2018/2001 des Europäischen Parlaments und des Rates vom 11. Dezember 2018 zur Förderung der Nutzung von Energie aus erneuerbaren Quellen

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 • Basics of fluid dynamics • 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. 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 . 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 • respectfully work together as a team and discuss technical tasks • participate in subject-specific and interdisciplinary discussions, • develop cooperated solutions • 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 Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory 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). 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 • 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 • basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition • Incineration techniques: grate firing, ash transfer, boiler • Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination • 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	
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 Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory 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
	  ◦ Water levels
	  ◦ Currents
	  ◦ Waves
	  ◦ Ice
	• Planning and Design in Coastal Engineering
	  ◦ Functional and constructional design
	  ◦ Determination of design parameters
	  ◦ Design-approaches
	    ▪ Filter
	    ▪ Rubble mound constructions
	    ▪ Piles
	    ▪ Vertical constructions

Literature	Coastal Engineering Manual, CEM 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 Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory 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 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. 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 Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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. • 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) • Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download) • 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 • Participatory Approaches • Rainwater Harvesting • Ecological Sanitation Principles and practical examples • Permaculture Principles of Rural Development • Performance and Resilience of Organic Small Farms • Going Further: The TUHH Toolbox for Rural Development • EMAS Technologies, Low cost drinking water supply
Literature	• Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk • Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press

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. 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 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 Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 • Sediment transport • Morphology • Technical solution for the protection of sandy coasts ◦ Construction in direction of the coast ◦ Constructions perpendicular to the coast ◦ Other Concepst • Calculation approaches and numerical models Flood Protection • Classification of constructions / measures • Dikes • Dunes • Foreland - constructions • Flood-Protection Walls • Drainage of the hinterland
Literature	Vorlesungsumdruck 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 • 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 Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 Analyzing the Audience, purpose and occasion Constructing and delivering effective technical presentations How to write an abstract How to write a scientific paper Developing competitive and persuasive research proposals Databases and resources available for water and environmental research Individual proposal on water and environmental research Individual project on water and environmental research Presentation on water and environmental research
Literature	• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9 • 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 - Sources of microplastics in environment - Microplastics sampling; Characterization of microplastics - Distribution of microplastics in terrestrial environments - Fate of microplastics in terrestrial environments - Project discussion - Effects of microplastics on terrestrial environments - Health risks of microplastics in environments - Project presentations by all students
Literature	- Microplastics in Terrestrial Environments (2021), Edited by Defu He and Yongming Luo - Particulate Plastics in Terrestrial and Aquatic Environments (2020), Edited by Nanthi S. Bolan et al. - 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 Analyzing the Audience, purpose and occasion Constructing and delivering effective technical presentations How to write an abstract How to create a scientific poster How to write a scientific paper Developing competitive and persuasive research proposals Individual project (report and presentation) related to soil, water and environmental research
Literature	• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9 • 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 • Hydromechanics, Hydraulics • 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 • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-based Solutions (NBS) for Coastal Protection
Skills	• Critical thinking: analysis of processes and relations, assessment of needs for action • Creative thinking: development of adaptation strategies and adaptation measures • Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods • Consideration of complex tasks
Personal Competence	
Social Competence	• Working in heterogenous groups • Working in international groups • Working with different scientific / non-scientific disciplines • Self reflection
Autonomy	• Application oriented use of knowledge and skills • 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 Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 • General Impacts of Climate Change on Wind Regime and Water Cycle • Consequences of Climate Change for Coastal Processes • Coastal Protection in Taiwan and Germany • Fundamentals of Climate Adaptation • Nature-Based Solutions (NBS) for Coastal Protection
Literature	• Materials provided on eLearning Platform (HOOU Platform) • 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	
Knowledge	
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	Subject theoretical and practical work
Examination duration and scale	Report & Präsentation
Assignment for the Following Curricula	Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 Metobolism of Microorganisms Kinetic of mirobiotic processes Calculation of bioreactor for wastewater treatment Concepts of Wastewater treatment Design of WWTP Excursion to a WWTP Biofilms Biofim Reactors Anaerobic Wastewater and sldge treatment resources oriented sanitation technology Future challenges of wastewater treatment

Literature	**Gujer, Willi** Siedlungswasserwirtschaft : mit 84 Tabellen 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 Berlin [u.a.] : Springer, 2007 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Imhoff, Karl** (Imhoff, Klaus R.;) Taschenbuch der Stadtentwässerung : mit 10 Tafeln ISBN: 3486263331 ((Gb.)) München [u.a.] : Oldenbourg, 1999 TUB_HH_Katalog **Lange, Jörg** (Otterpohl, Ralf; Steger-Hartmann, Thomas;) Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334 Donaueschingen-Pfohren : Mall-Beton-Verl., 2000 TUB_HH_Katalog **Mudrack, Klaus** (Kunst, Sabine;) Biologie der Abwasserreinigung : 18 Tabellen ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903 Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003 TUB_HH_Katalog **Tchobanoglous, George** (Metcalf & Eddy, Inc., ;) Wastewater engineering : treatment and reuse ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk)) Boston [u.a.] : McGraw-Hill, 2003 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Kunz, Peter** Umwelt-Bioverfahrenstechnik Vieweg, 1992 **Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt** (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, ;) Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe aus der Abwasserbehandlung, Kleinkläranlagen ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL: http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf Weimar : Universitätsverl, 2006 TUB_HH_Katalog **Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall** DWA-Regelwerk Hennef : DWA, 2004 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 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 reuse of reclaimed municipal wastewater Precipitation Flocculation Depth filtration Membrane Processes Activated carbon adsorption Ozonation "Advanced Oxidation Processes" Disinfection
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 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) Industrial wastewater Processes for industrial wastewater treatment Precipitation Flocculation Activated carbon adsorption Recalcitrant organic compounds
Literature	Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003 Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987 Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007 Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006 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	
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 Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 Civil Engineering: Specialisation Geotechnical Engineering: Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory 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
	  ◦ Water levels
	  ◦ Currents
	  ◦ Waves
	  ◦ Ice
	• Planning and Design in Coastal Engineering
	  ◦ Functional and constructional design
	  ◦ Determination of design parameters
	  ◦ Design-approaches
	    ▪ Filter
	    ▪ Rubble mound constructions
	    ▪ Piles
	    ▪ Vertical constructions

Literature	Coastal Engineering Manual, CEM 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. 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. 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 Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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. • 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) • Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download) • 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 • Participatory Approaches • Rainwater Harvesting • Ecological Sanitation Principles and practical examples • Permaculture Principles of Rural Development • Performance and Resilience of Organic Small Farms • Going Further: The TUHH Toolbox for Rural Development • EMAS Technologies, Low cost drinking water supply
Literature	• Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk • Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press

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 Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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 Tracer modelling Activated Sludge Model Wastewater Treatment Plant Modelling (continously and SBR) Sludge Treatment (ADM, aerobic autothermal) Biofilm Modelling
Literature	**Henze, Mogens** (Seminar on Activated Sludge Modelling, ; Kollekolle Seminar on Activated Sludge Modelling, ;) 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 ISBN: 1843394146 [London] : IWA Publ., 2002 TUB_HH_Katalog **Henze, Mogens** Activated sludge models ASM1, ASM2, ASM2d and ASM3 ISBN: 1900222248 London : IWA Publ., 2002 TUB_HH_Katalog **Henze, Mogens** Wastewater treatment : biological and chemical processes ISBN: 3540422285 (Pp.) Berlin [u.a.] : Springer, 2002 TUB_HH_Katalog **Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;) Fundamentals of biological wastewater treatment ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm Weinheim : WILEY-VCH, 2007 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. 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 **OpenModelica - Modelica Tutorial:** https://openmodelica.org/index.php/useresresources/userdocumentation **OpenModelica - Users Guide:** https://openmodelica.org/index.php/useresresources/userdocumentation **Peter Fritzson:** Principles of Object-Oriented Modeling and Simulation with Modelica 2.1,Wiley-IEEE Press, ISBN 0-471-471631. **MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005. **Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996. **DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.

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 Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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. 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. 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. • Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands • 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 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 Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Environmental Engineering: Specialisation Environment and Climate: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory 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
	• Sediment transport
	• Morphology
	• Technical solution for the protection of sandy coasts
	  ◦ Construction in direction of the coast
	  ◦ Constructions perpendicular to the coast
	  ◦ Other Concepst
	• Calculation approaches and numerical models
	Flood Protection
	• Classification of constructions / measures
	• Dikes
	• Dunes
	• Foreland - constructions
	• Flood-Protection Walls
	• Drainage of the hinterland

Literature	Vorlesungsumdruck 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 • 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; • Good knowledge in urban drainage; • Good knowledge of wastewater treatment techniques; • 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 Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Specialisation Water Quality and Water Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory 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: • Regulatory Framework (e.g. WFD) • Main instruments for the water management and protection • In depth knowledge of relevant measures of water pollution control • Urban drainage, treatment options in different regions on the world • Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration • Case Studies and Field Trips
Literature	The literature listed below is available in the library of the TUHH. • Water and wastewater technology Hammer, M. J. 1., & . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International. • Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill. • 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 ... • ... 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. • ... 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. • ... 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 ... • ... can select suitable methods for the respective subject-related professional problem, apply them and develop them further as required. • ... 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. • ... acquire new academic knowledge in their subject area and critically evaluate it.
Personal Competence	
Social Competence	Dual students ... • ... 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. • ... 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 ... • ... 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. • ... work in-depth in a partially unknown area within the discipline and acquire the information required to do so. • ... 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 Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Data Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Logistics, Infrastructure and Mobility: Thesis: Compulsory Aeronautics: Thesis: Compulsory Materials Science and Engineering: Thesis: Compulsory Materials Science: Thesis: Compulsory Mechanical Engineering and Management: Thesis: Compulsory Mechatronics: Thesis: Compulsory Biomedical Engineering: Thesis: Compulsory Microelectronics and Microsystems: Thesis: Compulsory

	Product Development, Materials and Production: Thesis: Compulsory Renewable Energies: Thesis: Compulsory Naval Architecture and Ocean Engineering: Thesis: Compulsory Theoretical Mechanical Engineering: Thesis: Compulsory Process Engineering: Thesis: Compulsory Water and Environmental Engineering: Thesis: Compulsory