



## **Module Manual**

Master of Science (M.Sc.)

# **Water and Environmental Engineering**

Cohort: Winter Term 2024

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## Program description

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### Content

#### Master of Science in 'Water and Environmental Engineering'

The Master of Science in Water and Environmental Engineering gives students a choice of three areas of specialization - Water, Environment and City. Graduates of the Master in Water and Environmental Engineering are able to translate the engineering, mathematical and scientific knowledge gained on the course into practice in order to analyze problems scientifically and solve them even when they are unusually or incompletely defined and have complex specifications. Graduates have the ability to work independently, to apply the methods and processes required to solve technical and planning problems, and to apply, critically scrutinize, and further develop new findings. They are also qualified to plan exacting (household) water management projects and projects geared to environmental protection and to plan them paying due attention to the necessary clarifications and examination of existing information and resources. They can

- Collaborate successfully with professional and non-professional players in public administration, industry, and academia
- Independently define research tasks for theoretical and experimental exploration of environmental and water management issues and plan and execute projects in those areas
- Responsibly assess and take into account the concerns of those affected by planning and implementation and of society in general
- work together in international teams on international subjects with cross-cultural competence.

**Core Qualification**

<b>Module M0523: Business &amp; Management</b>	
<b>Module Responsible</b>	Prof. Matthias Meyer
<b>Admission Requirements</b>	Successful completion of the modul "Foundations of Management"
<b>Recommended Previous Knowledge</b>	None
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b> <i>Knowledge</i> <ul style="list-style-type: none"> <li>• Students are able to find their way around selected special areas of management within the scope of business management.</li> <li>• Students are able to explain basic theories, categories, and models in selected special areas of business management.</li> <li>• Students are able to interrelate technical and management knowledge.</li> </ul> <i>Skills</i> <ul style="list-style-type: none"> <li>• Students are able to apply basic methods in selected areas of business management.</li> <li>• Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.</li> </ul> <b>Personal Competence</b> <i>Social Competence</i> <ul style="list-style-type: none"> <li>• Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems</li> </ul> <i>Autonomy</i> <ul style="list-style-type: none"> <li>• Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.</li> </ul>	
<b>Workload in Hours</b>	Depends on choice of courses
<b>Credit points</b>	6

**Courses**

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

Module M0524: Non-technical Courses for Master	
<b>Module Responsible</b>	Dagmar Richter
<b>Admission Requirements</b>	None
<b>Recommended Previous Knowledge</b>	None
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b> <i>Knowledge</i>	<p><b>The Nontechnical Academic Programms (NTA)</b></p> <p>imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its <b>teaching architecture</b>, in its <b>teaching and learning arrangements</b>, in <b>teaching areas</b> and by means of teaching offerings in which students can qualify by opting for <b>specific competences</b> and a <b>competence level</b> at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses.</p> <p><b>The Learning Architecture</b></p> <p>consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling of TUHH degree courses.</p> <p>The learning architecture demands and trains independent educational planning as regards the individual development of competences. It also provides orientation knowledge in the form of "profiles".</p> <p>The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters during the course of studies.</p> <p><b>Teaching and Learning Arrangements</b></p> <p>provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in specific courses.</p> <p><b>Fields of Teaching</b></p> <p>are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way.</p> <p>The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal-oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations.</p> <p><b>The Competence Level</b></p> <p>of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc.</p> <p>This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life.</p> <p><b>Specialized Competence (Knowledge)</b></p> <p>Students can</p> <ul style="list-style-type: none"> <li>• explain specialized areas in context of the relevant non-technical disciplines,</li> <li>• outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area,</li> <li>• different specialist disciplines relate to their own discipline and differentiate it as well as make connections,</li> <li>• sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity,</li> <li>• Can communicate in a foreign language in a manner appropriate to the subject.</li> </ul>
<b>Professional Competence</b> <i>Skills</i>	<p><b>Professional Competence (Skills)</b></p> <p>In selected sub-areas students can</p> <ul style="list-style-type: none"> <li>• apply basic and specific methods of the said scientific disciplines,</li> <li>• question a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline,</li> <li>• to handle simple and advanced questions in aforementioned scientific disciplines in a successful manner,</li> <li>• justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.</li> </ul>



Module M1974: Environmental microbiology and analytics				
Courses				
Title		Typ	Hrs/wk	CP
Environmental Analysis (L0354)		Lecture	2	3
Environmental microbiology (L3223)		Lecture	2	3
<b>Module Responsible</b>	Dr. Dorothea Rechtenbach			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Fundamentals of inorganic/organic chemistry and biology (knowledge acquired at school).			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	On completion of this module, students will be able to describe the mechanisms of biological systems. They will know the main biological metabolic routes and can categorise their influence on global metabolic routes. They will be familiar with the basic analytical methods for investigating and assessing the quality of various environmental compartments.			
<i>Skills</i>	On completion of this module, students will be able to categorise which metabolism will predominate under which environmental conditions. Students will be able to apply the theoretical principles they have learnt to exemplary sites and assess the resulting relationships from a technical and conceptual perspective. They will be able to draw comparisons on different investigation strategies and techniques. Model projects can be devised and treated.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students are able to organize working processes within a team in a targeted way and based on the division of labour.			
<i>Autonomy</i>	Students can independently exploit sources, acquire the particular knowledge of the subject and apply it to new problems.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Water and Environmental Engineering: Core Qualification: Compulsory			

<b>Course L0354: Environmental Analysis</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Dorothea Rechtenbach, Dr. Henning Mangels
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Introduction</p> <p>Sampling in different environmental compartments, sample transportation, sample storage</p> <p>Sample preparation</p> <p>Photometry</p> <p>Wastewater analysis</p> <p>Introduction into chromatography</p> <p>Gas chromatography</p> <p>HPLC</p> <p>Mass spectrometry</p> <p>Optical emission spectrometry</p> <p>Atom absorption spectrometry</p> <p>Quality assurance in environmental analysis</p>
<b>Literature</b>	<p>Roger Reeve, Introduction to Environmental Analysis, John Wiley &amp; Sons Ltd., 2002 (TUB: USD-728)</p> <p>Pradyot Patnaik, Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes, CRC Press, Boca Raton, 2010 (TUB: USD-716)</p> <p>Chunlong Zhang, Fundamentals of Environmental Sampling and Analysis, John Wiley &amp; Sons Ltd., Hoboken, New Jersey, 2007 (TUB: USD-741)</p> <p>Miroslav Radojević, Vladimir N. Bashkin, Practical Environmental Analysis RSC Publ., Cambridge, 2006 (TUB: USD-720)</p> <p>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 &amp; Co. KGaA, Weinheim, 2007 (TUB: CHF-350)</p> <p>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)</p> <p>K. Robards, P. R. Haddad, P. E. Jackson, Principles and Practice of Modern Chromatographic Methods, Academic Press</p> <p>G. Schwedt, Chromatographische Trennmethoden, Thieme Verlag</p> <p>H. M. McNair, J. M. Miller, Basic Gas Chromatography, Wiley</p> <p>W. Gottwald, GC für Anwender, VCH</p> <p>B. A. Bidlingmeyer, Practical HPLC Methodology and Applications, Wiley</p> <p>K. K. Unger, Handbuch der HPLC, GIT Verlag</p> <p>G. Aced, H. J. Möckel, Liquidchromatographie, VCH</p> <p>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: <a href="http://files.instrument.com.cn/bbs/upfile/2006291448.pdf">http://files.instrument.com.cn/bbs/upfile/2006291448.pdf</a></p> <p>Atomic absorption spectrometry: theory, design and applications, ed. by S. J. Haswell 1991 (TUB: 2727-5614)</p> <p>Royal Society of Chemistry, Atomic absorption spectrometry (<a href="http://www.kau.edu.sa/Files/130002/Files/6785_AAs.pdf">http://www.kau.edu.sa/Files/130002/Files/6785_AAs.pdf</a>)</p>

<b>Course L3223: Environmental microbiology</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Johannes Gescher
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	This lecture deals with the importance of microorganisms for biological material cycles and the health of water and soil. After the development of biochemical and cell biological basics, methods are presented that are necessary to investigate microbial communities and their activity. In addition, the role of microorganisms in the biogas process and in the biorefinery is discussed. The third part presents methods for purifying air, water and soil as well as environmentally friendly production processes involving microorganisms.
<b>Literature</b>	Umweltmikrobiologie; Reineke, W. und Schlömann, M. (2015) 2. Aufl., Springer Spektrum Verlag  Brock Mikrobiologie; Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley, David A. Stahl (2020) 15. Aufl., Pearson Studium Verlag

Module M2004: Sustainable Circular Economy			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Circular Economy (L3264)		Seminar	2                  3
Environment and Sustainability (L0319)		Lecture	2                  3
<b>Module Responsible</b>	Prof. Kerstin Kuchta		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	none		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	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:		
<i>Knowledge</i>	<ul style="list-style-type: none"> <li>• basics in safety and reliability of technical facilities</li> <li>• risk assessment and reliability analysis methods</li> <li>• Circularity of material</li> <li>• Identification and evaluation of material flows</li> <li>• energy production and supply</li> <li>• sustainable product design</li> </ul>		
<i>Skills</i>	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.		
<b>Personal Competence</b>	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.		
<i>Social Competence</i>			
<i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	Elaboration and presentation (45 minutes in groups)		
<b>Assignment for the Following Curricula</b>	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 Chemical and Bioprocess Engineering: Specialisation Chemical and Bio 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	
<b>Typ</b>	Seminar
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Marco Ritzkowski
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	
<b>Literature</b>	

<b>Course L0319: Environment and Sustainability</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>The following list shows examples:</p> <ul style="list-style-type: none"> <li>• Production and use of biochar</li> <li>• Energy production with algae</li> <li>• Environmentally friendly product design</li> <li>• Clean development mechanisms</li> <li>• Democracy and energy</li> <li>• Alternative mobility</li> </ul>
<b>Literature</b>	Wird in der Veranstaltung bekannt gegeben.

## Specialization Cities

### Module M0923: Integrated Transportation Planning

#### Courses

Title	Typ	Hrs/wk	CP
Integrated Transportation Planning (L1068)	Project-/problem-based Learning	4	6
<b>Module Responsible</b>	Prof. Carsten Gertz		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineerin		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	Students are able to: <ul style="list-style-type: none"> <li>describe interdependencies between land-use/location choice and transportation/mobility behaviour</li> <li>explain and evaluate the social, ecological and economic effects of transport and land-use policy measures.</li> <li>relate current issues in the area of integrated transport planning and formulate an opinion on them.</li> </ul>		
<i>Skills</i>	Students are able to: <ul style="list-style-type: none"> <li>quantify important parameters, which influence travel demand or are influenced by it.</li> <li>comprehensively examine a pre-defined or self-selected topic from a transportation studies perspective and document the results in accordance with scientific conventions.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	Students are able to: <ul style="list-style-type: none"> <li>provide feedback on topical contents and their teaching.</li> <li>constructively handle feedback on their own work.</li> <li>produce results in group work and document these.</li> </ul>		
<i>Autonomy</i>	Students are able to: <ul style="list-style-type: none"> <li>assess potential consequences of their future professional activities</li> <li>independently plan working on a pre-defined project topic, acquire the necessary knowledge and use appropriate means for its execution.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	written assignment with presentation during the semester		
<b>Assignment for the Following Curricula</b>	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 Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Compulsory		

<b>Course L1068: Integrated Transportation Planning</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Carsten Gertz, Dr. Philine Gaffron, Jacqueline Bianca Maaß
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The course will provide students with an understanding of interdependencies between land-use and transportation. Specific topics include a.o.:</p> <ul style="list-style-type: none"> <li>• interactions between transport and the environment and consequent limitations</li> <li>• characteristics of integrated planning</li> <li>• complex planning processes</li> <li>• interdependencies of location choice and mobility behaviour</li> <li>• transport and land-use policies</li> <li>• project on current issues in transportation studies</li> </ul>
<b>Literature</b>	<p>Kutter, Eckhard (2019) Stadtstruktur und Erreichbarkeit in der postfossilen Zukunft. Erich Schmidt Verlag, Berlin.</p> <p>Gies, Huber u. a. (Hrsg.) (93. Ergänzung 2022) Handbuch der kommunalen Verkehrsplanung. Herbert Wichmann Verlag, Berlin, Offenbach. (Loseblattsammlung mit kontinuierlichen Ergänzungen)</p>

Module M0827: Modeling in Water Management				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Groundwater Modeling using Modflow (L0543)		Lecture	1	1
Groundwater Modeling using Modflow (L0544)		Recitation Section (small)	2	2
Modeling of Water Supply Network (L0875)		Project-/problem-based Learning	2	3
<b>Module Responsible</b>	Dr. Klaus Johannsen			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Groundwater <ul style="list-style-type: none"> <li>groundwater hydraulics and transport of substances</li> </ul> Pipe Systems <ul style="list-style-type: none"> <li>Knowledge on urban water infrastructures, in particular drinking water systems and urban drainage systems including special structures</li> <li>Hydraulics of drinking water supply systems and sewer systems</li> <li>Basic knowledge on water management</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.			
<i>Skills</i>	The students are able to construct and apply scientific groundwater models independently. They can work on different scenarios and can compare or assess different solutions for existing problems by application of selected software products. The students are able to use different software solutions (e.g. EPANET, EPA-SWMM).			
<b>Personal Competence</b>				
<i>Social Competence</i>	Wird nicht vermittelt.			
<i>Autonomy</i>	Wird nicht vermittelt.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	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 Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory			

Course L0543: Groundwater Modeling using Modflow	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Sonja Götz
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical background of the model, students do work with the model PMWIN for practical case studies.
<b>Literature</b>	MODFLOW-Handbuch  Chiang, Wen Hsien: PMWIN

<b>Course L0544: Groundwater Modeling using Modflow</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Sonja Götz
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

<b>Course L0875: Modeling of Water Supply Network</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014.

Module M0828: Urban Environmental Management			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Noise Protection (L1109)		Lecture	2                  2
Urban Infrastructures (L0874)		Project-/problem-based Learning	2                  4
<b>Module Responsible</b>	Dr. Dorothea Rechtenbach		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Knowledge on Urban planning</li> <li>• Knowledge on measures for climate protection</li> <li>• General knowledge of scientific writing/working</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students can work together in international groups.</p> <p><i>Autonomy</i> 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.</p>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	Written Report plus oral Presentation		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Martin Jäschke
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	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

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<b>Course L0874: Urban Infrastructures</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Dorothea Rechtenbach
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Problem Based Learning</p> <p>Main topics are:</p> <ul style="list-style-type: none"> <li>• Central vs. Decentral Wastewater Treatment.</li> <li>• Compaction of Cities.</li> <li>• Car Free Cities.</li> <li>• Multifunctional Places in Cities.</li> <li>• The Sustainability of Freight Transport in Cities.</li> </ul>
<b>Literature</b>	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	
<b>Module Responsible</b>	Prof. Peter Fröhle			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Fundamentals of Hydromechanics, Hydraulics, Hydrology and Hydraulic Engineering; Hydraulic Engineering I and Hydraulic Engineering II			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	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.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students are able to deploy their gained knowledge in applied problems of the practical nature-based hydraulic engineering. Additionally, they will be able to work in team with engineers of other disciplines.			
<i>Autonomy</i>	The students will be able to independently extend their knowledge and apply it to new problems.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	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.			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Edgar Nehlsen, Prof. Peter Fröhle
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Introduction to numerical flow modelling</p> <ul style="list-style-type: none"> <li>• Processes affecting the flow</li> <li>• Examples and applications of numerical models</li> <li>• Procedure of numerical modelling</li> <li>• Model concept</li> </ul> <p>Basic equations of hydrodynamics</p> <ul style="list-style-type: none"> <li>• Saint-Venant equations</li> <li>• Euler Equations</li> <li>• Navier-Stokes equations</li> <li>• Reynolds-averaged Navier-Stokes equations</li> <li>• Shallow water equations</li> </ul> <p>Solving schemes</p> <ul style="list-style-type: none"> <li>• Numerical discretization</li> <li>• Solution algorithms</li> <li>• Convergence</li> </ul>
<b>Literature</b>	<p>Vorlesungsskript</p> <p>Literaturempfehlungen</p> <p>Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt).</p> <p>Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series).</p> <p>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).</p> <p>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).</p> <p>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).</p> <p>Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter <a href="http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html">http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html</a>.</p> <p>IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92.</p> <p>Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology.</p> <p>Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83).</p> <p>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).</p> <p>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).</p>

<b>Course L0961: Nature-Oriented Hydraulic Engineering / Integrated Flood Protection</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Natasa Manojlovic, Prof. Peter Fröhle
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Regime-Theory and application for the development of environmental guiding principles of rivers</li> <li>• Engineering - biological measures for the stabilization of rivers</li> <li>• Risk management in flood protection</li> <li>• Design techniques in technical flood protection</li> <li>• Methods for the assessment of flood caused damages</li> </ul>
<b>Literature</b>	Vorlesungsumdruck

Module M0871: Hydrological Systems	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
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
<b>Module Responsible</b>	Prof. Peter Fröhle
<b>Admission Requirements</b>	None
<b>Recommended Previous Knowledge</b>	Fundamentals of Hydromechanics and Hydraulic Engineering: Hydraulic Engineering I and Hydraulic Engineering II
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
<i>Knowledge</i>	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.
<i>Skills</i>	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.
<b>Personal Competence</b>	
<i>Social Competence</i>	The students are able to deploy their gained knowledge in applied problems of the hydrology and water management. Additionally, they will be able to work in team with engineers of other disciplines.
<i>Autonomy</i>	The students will be able to independently extend their knowledge and apply it to new problems
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Credit points</b>	6
<b>Course achievement</b>	None
<b>Examination</b>	Written exam
<b>Examination duration and scale</b>	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.
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory 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 Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

Course L0289: Applied Surface Hydrology	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Peter Fröhle
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Basics of hydrology: <ul style="list-style-type: none"> <li>• Hydrological cycle</li> <li>• Data acquisition</li> <li>• Data analyses and statistical assessment</li> <li>• Statistics of extremes</li> <li>• Regionalization methods for hydrological values</li> <li>• Rainfall-run-off modelling on the basis of a unit hydrograph concepts</li> <li>• Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool.</li> </ul>
<b>Literature</b>	<a href="http://de.wikipedia.org/wiki/Kalypso_(Software)">http://de.wikipedia.org/wiki/Kalypso_(Software)</a> <a href="http://kalypso.bjoernsen.de/">http://kalypso.bjoernsen.de/</a> <a href="http://sourceforge.net/projects/kalypso/">http://sourceforge.net/projects/kalypso/</a>

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

<b>Course L0295: Interaction Water - Environment in Fluvial Areas</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Peter Fröhle
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	-

Module M0874: Wastewater Systems			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Dr. Joachim Behrendt		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Knowledge of wastewater management and the key processes involved in wastewater treatment.		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	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.		
<i>Skills</i>	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.		
<b>Personal Competence</b>			
<i>Social Competence</i>	Social skills are not targeted in this module.		
<i>Autonomy</i>	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.		
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Joachim Behrendt
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Charaterisation of Wastewater Metabolism of Microorganisms Kinetic of microbiotic processes Calculation of bioreactor for wastewater treatment Concepts of Wastewater treatment Design of WWTP Excursion to a WWTP Biofilms Biofim Reactors Anaerobic Wastewater and sludge treatment resources oriented sanitation technology Future challenges of wastewater treatment
<b>Literature</b>	<b>Gujer, Willi</b> 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](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-Pföhren : 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](http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf) URL:  
[http://www.gbv.de/dms/weimar/abs/513989765\\_abs.pdf](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](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	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Joachim Behrendt
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

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

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

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
<b>Module Responsible</b>	Prof. Ralf Otterpohl			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge of the global situation with rising poverty, soil degradation, migration to cities, lack of water resources and sanitation			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	Students are able to design ecological settlements for different geographic and socio-economic conditions for the main climates around the world.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students are able to develop a specific topic in a team and to work out milestones according to a given plan.			
<i>Autonomy</i>	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	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 semester in the StudIP course module handbook.			
<b>Assignment for the Following Curricula</b>	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			

<b>Course L1229: Ecological Town Design - Water, Energy, Soil and Food Nexus</b>	
<b>Typ</b>	Seminar
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Ralf Otterpohl
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Participants Workshop: Design of the most attractive productive Town</li> <li>• Keynote lecture and video</li> <li>• The limits of Urbanization / Green Cities</li> <li>• The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities</li> <li>• Global Ecovillage Network: Upsides and Downsides around the World</li> <li>• Visit of an Ecovillage</li> <li>• Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competition</li> <li>• TUHH Rural Development Toolbox</li> <li>• Integrated New Town Development</li> <li>• Participants workshop: Design of New Towns: Northern, Arid and Tropical cases</li> <li>• Outreach: Participants campaign</li> <li>• City with the Rural: Resilience, quality of live and productive biodiversity</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• 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</li> <li>• <a href="http://youtu.be/9hmkgn0nBgk">http://youtu.be/9hmkgn0nBgk</a> (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> <li>• TEDx New Town Ralf Otterpohl: <a href="http://youtu.be/_M0J2u9BrbU">http://youtu.be/_M0J2u9BrbU</a></li> </ul>

<b>Course L0939: Water &amp; Wastewater Systems in a Global Context</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Ralf Otterpohl
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Keynote lecture and video</li> <li>• Water &amp; Soil: Water availability as a consequence of healthy soils</li> <li>• Water and it's utilization, Integrated Urban Water Management</li> <li>• Water &amp; Energy, lecture and panel discussion pro and con for a specific big dam project</li> <li>• Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation</li> <li>• Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches</li> <li>• Why are there excreta in water? Public Health, Awareness Campaigns</li> <li>• Rehearsal session, Q&amp;A</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press</li> <li>• Liu, John D.: <a href="http://eempc.org/hope-in-a-changing_climate/">http://eempc.org/hope-in-a-changing_climate/</a> (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda)</li> <li>• <a href="http://youtu.be/9hmkgn0nBgk">http://youtu.be/9hmkgn0nBgk</a> (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> </ul>

Module M0922: City Planning			
Courses			
Title	Typ	Hrs/wk	CP
City Planning (L1066)	Project-/problem-based Learning	4	6
<b>Module Responsible</b>	Prof. Carsten Gertz		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	for "Principles of Urban Planning": none for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	Students are able to: <ul style="list-style-type: none"> <li>• use technical terms of urban planning.</li> <li>• describe the main determinants of urban development.</li> <li>• explain and compare different possibilities of how urban development can be influenced.</li> <li>• discuss requirements for public streetscapes.</li> <li>• explain the importance of street design.</li> </ul>		
<i>Skills</i>	Students are able to: <ul style="list-style-type: none"> <li>• read and analyze urban development concepts and designs for streetscapes</li> <li>• appraise such concepts in the context of competing requirements.</li> <li>• design, justify and reflect their own solutions for concrete examples.</li> </ul>		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students are able to: <ul style="list-style-type: none"> <li>• discuss intermediate results with each other.</li> <li>• constructively accept feedback on their own work.</li> <li>• provide constructive feedback to others.</li> </ul>		
<i>Autonomy</i>	Students are able to: <ul style="list-style-type: none"> <li>• independently complete a written report including drawings following a broadly pre-defined process.</li> <li>• assess the consequences of their proposed solutions.</li> <li>• independently acquire knowledge and apply this to new issues or problem areas.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	written assignment, designwork during the semester		
<b>Assignment for the Following Curricula</b>	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 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		

<b>Course L1066: City Planning</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Carsten Gertz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>„Principles of Urban Planning“ deals with the determinants of urban development and their interactions. Topics include:</p> <ul style="list-style-type: none"> <li>• legal framework,</li> <li>• instruments and methods of planning,</li> <li>• functional requirements,</li> <li>• stakeholders and actors</li> <li>• basic design requirements</li> <li>• different planning levels and</li> <li>• historical contexts.</li> </ul> <p>The objective of the course is for students to acquire a basic understanding of urban development problems and approaches for solving them. They will also be able to comprehend the process of urban planning. The course also covers the various functional and aesthetic requirements for designing streetscape as the most important elements of public space.</p> <p>The project work deals with a real life scenario and includes drawing up a development plan, an urban design concept, a building masterplan and a street redesign.</p>
<b>Literature</b>	<p>Albers, Gerd; Wekel, Julian (2021) Stadtplanung: Eine illustrierte Einführung. 4. überarbeitete Auflage. Primus Verlag. Darmstadt.</p> <p>Frick, Dieter (2011) Theorie des Städtebaus: Zur baulich-räumlichen Organisation von Stadt. 3. veränderte Auflage. Wasmuth-Verlag. Tübingen</p> <p>Jonas, Carsten (2009) Die Stadt und ihr Grundriss. Wasmuth-Verlag. Tübingen</p> <p>Kostof, Spiro; Castillo, Greg (1998) Die Anatomie der Stadt. Geschichte städtischer Strukturen. Campus-Verlag. Frankfurt/New York.</p>

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

Courses			
Title	Typ	Hrs/wk	CP
Water and Environment (L2754)	Project-/problem-based Learning	3	3
Water and Environment (L2753)	Lecture	3	3
<b>Module Responsible</b>	Prof. Nima Shokri		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic knowledge in water and environmental research, Hydrology		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.</p> <p><i>Autonomy</i> 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.</p>		
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Subject theoretical and practical work		
<b>Examination duration and scale</b>	Report and Presentation		
<b>Assignment for the Following Curricula</b>	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**

<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Dr. Salome Shokri-Kuehni
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

**Course L2753: Water and Environment**

<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Nima Shokri
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	NA

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	
<b>Module Responsible</b>	Prof. Kay Smarsly			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	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.			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	The students will gain insights into operating state-of-the-art smart sensor systems, used for monitoring a wide range of physical processes relevant to engineering, such as environmental, structural, or comfort monitoring. The students will be capable of devising monitoring strategies of physical processes as part of group projects, tailored to their knowledge backgrounds, and to implement the strategies in smart wireless sensor nodes, using embedded computing and programming. Finally, the students will be able to document the findings of their projects in short reports.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students will be able to work in groups, share parts of the work for their projects, and develop communication skills, towards achieving the common project goals.			
<i>Autonomy</i>	The students will be able to gain a solid basis on approaching and solving problems in engineering, as well as on documenting results, through their involvement in their monitoring group projects.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written elaboration			
<b>Examination duration and scale</b>	10 pages of work with 15-minute oral presentation			
<b>Assignment for the Following Curricula</b>	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 Computer Science: Specialisation II: Intelligence 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 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	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kay Smarsly
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Course L2763: Smart Monitoring	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kay Smarsly
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Module M1878: Sustainable energy from wind and water				
Courses				
Title	Typ	Hrs/wk	CP	
Offshore Geotechnical Engineering (L0067)	Lecture	1	1	
Hydro Power Use (L0013)	Lecture	1	1	
Wind Turbine Plants (L0011)	Lecture	2	3	
Wind Energy Use - Focus Offshore (L0012)	Lecture	1	1	
<b>Module Responsible</b>	Dr. Marvin Scherzinger			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Module: Technical Thermodynamics I, Module: Technical Thermodynamics II, Module: Fundamentals of Fluid Mechanics			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe.</p> <p>Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice.</p> <p><i>Skills</i> Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students can discuss scientific tasks sujet-specificly and multidisciplinary within a seminar.</p> <p><i>Autonomy</i> Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.</p>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	180 min			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: 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 Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: 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 L0067: Offshore Geotechnical Engineering	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Jan Dührkop
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Overview and Introduction Offshore Geotechnics</li> <li>• Introduction to Soil Mechanics</li> <li>• Offshore soil investigation</li> <li>• Focus on cyclical effects</li> <li>• Geotechnical design of offshore foundations</li> <li>• Monopiles</li> <li>• Jackets</li> <li>• Heavyweight foundations</li> <li>• Geotechnical preliminary exploration for the use of lift boats and platforms</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Randolph, M. and Gourvenec, S (2011): Offshore Geotechnical Engineering. Spon Press.</li> <li>• Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London</li> <li>• BSH-Standard Baugrunderkundung für Offshore-Windenergieparks</li> <li>• Lesny K. (2010): Foundations for Offshore Wind Turbines. VGE Verlag, Essen.</li> <li>• EA-Pfähle (2012): Empfehlungen des Arbeitskreises Pfähle der DGGT. Ernst &amp; Sohn, Berlin.</li> </ul>

Course L0013: Hydro Power Use	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Stefan Achleitner
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction, importance of water power in the national and global context</li> <li>• Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies</li> <li>• Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems</li> <li>• Construction of hydroelectric power plants: description of the individual components and their technical system interaction</li> <li>• Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc.</li> <li>• Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection</li> <li>• Hydropower and the Environment</li> <li>• Examples from practice</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage</li> <li>• Quaschnig, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage</li> <li>• Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage</li> <li>• von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage</li> <li>• Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006</li> </ul>

Course L0011: Wind Turbine Plants	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Rudolf Zellermann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Historical development</li> <li>• Wind: origins, geographic and temporal distribution, locations</li> <li>• Power coefficient, rotor thrust</li> <li>• Aerodynamics of the rotor</li> <li>• Operating performance</li> <li>• Power limitation, partial load, pitch and stall control</li> <li>• Plant selection, yield prediction, economy</li> <li>• Excursion</li> </ul>
<b>Literature</b>	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005

Course L0012: Wind Energy Use - Focus Offshore	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Martin Skiba
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering</li> <li>• Physical fundamentals for utilization of wind energy</li> <li>• Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships</li> <li>• Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures</li> <li>• Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection</li> <li>• Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics</li> <li>• Development and planning of offshore wind farms</li> <li>• Operation and optimization of offshore wind farms</li> <li>• Day excursion</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage</li> <li>• Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidelberg, 1997, 3. Auflage</li> <li>• Hau, E.: Windkraftanlagen; Springer, Berlin, Heidelberg, 2008, 4. Auflage</li> <li>• Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage</li> <li>• Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage</li> </ul>

Module M2002: Waste and Resource Management				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Waste management (L3261)		Project-/problem-based Learning	3	3
International waste concepts (L3259)		Lecture	2	2
International waste concepts (L3260)		Recitation Section (small)	1	1
<b>Module Responsible</b>	Prof. Kerstin Kuchta			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basics in process engineering			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	The students are able to describe waste as a resource as well as advanced technologies for recycling and recovery of resources from waste in detail. This covers collection, transport, treatment and disposal in national and international contexts.			
<i>Skills</i>	Students are able to select suitable processes for the treatment with respect to the national or cultural and developmental context. They can evaluate the ecological impact and the technical effort of different technologies and management systems.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students can work together as a team of 2-5 persons, 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 colleagues. Furthermore, they can give and accept professional constructive criticisms.			
<i>Autonomy</i>	Students can independently gain additional knowledge of the subject area and apply it in solving the given course tasks and projects.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	20 %	Written elaboration	
<b>Examination</b>	Presentation			
<b>Examination duration and scale</b>	PowerPoint presentation (10-15 minutes)			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Water and Traffic: 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 Chemical and Bioprocess Engineering: Specialisation Chemical and Bio process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Core Qualification: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory			

Course L3261: Waste management	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Rüdiger Siechau
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction into the "Waste Management" consisting of:                             <ul style="list-style-type: none"> <li>◦ Thermal Process (incinerator, RDF combustion)</li> <li>◦ Biological processes (Wet-/Dryfermentation)</li> <li>◦ technology, energy, emissions, approval , etc.</li> </ul> </li> <li>• Group work                             <ul style="list-style-type: none"> <li>◦ design of systems/plants for energy recovery from waste</li> <li>◦ The following points are to be processed:                                     <ul style="list-style-type: none"> <li>▪ Input: waste (fraction collection and transportation, current quantity, material flows , possible amount of development)</li> <li>▪ Plant (design, process diagram, technology, energy production)</li> <li>▪ Output (energy quantity / type, by-products)</li> <li>▪ Costs and revenues</li> <li>▪ Climate and resource protection (CO2 balance , substitution of primary raw materials / fossil fuels)</li> <li>▪ Location and approval (infrastructure , expiration authorization procedure)</li> <li>▪ Focus at the whole concept (advantages, disadvantages , risks and opportunities , discussion)</li> </ul> </li> </ul> </li> </ul>
<b>Literature</b>	Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010  Powerpoint-Folien in Stud IP

Course L3259: International waste concepts	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Waste avoidance and recycling are the focus of this lecture. Additionally, waste logistics ( Collection, transport, export, fees and taxes) as well as international waste shipment solutions are presented.</p> <p>Other specific wastes, e.g. industrial waste, treatment concepts will be presented and developed by students themselves</p> <p>Waste composition and production on international level, waste eulogistic, collection and treatment in emerging and developing countries.</p> <p>Single national projects and studies will be prepared and presented by students</p>
<b>Literature</b>	Basel convention

Course L3260: International waste concepts	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0982: Transportation Modelling			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Transportation Modelling (L1180)		Project-/problem-based Learning	4                  6
<b>Module Responsible</b>	Prof. Carsten Gertz		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> Students are able to understand the operation and potential applications of transport models.</p> <p><i>Skills</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• use travel demand modelling software packages for solving practical problems.</li> <li>• design a database structure for travel demand models.</li> <li>• assess modelling results.</li> <li>• appraise potential applications and limitations of such models.</li> </ul>		
<b>Personal Competence</b>	<p><i>Social Competence</i> Students are able to independently develop and document solutions.</p> <p><i>Autonomy</i> Students are able to:</p> <ul style="list-style-type: none"> <li>• independently organise, manage and solve set tasks.</li> <li>• independently prepare written reports.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	written assignment with presentation during the semester		
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Water and Traffic: Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory		

Course L1180: Transportation Modelling	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Carsten Gertz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Principles of transport modelling</li> <li>• Role of transport modelling in the planning process</li> <li>• Fundamentals of mobility behaviour</li> <li>• Design and evaluation of transport/mobility surveys</li> <li>• mode of operation and data requirements for different stages of modelling</li> <li>• Forecasting and scenarios in the transport planning</li> <li>• The range of model applications (from transport infrastructure planning over simulation of traffic flows to integrated land-use and transport models as well as the use of models for evaluating locations)</li> <li>• Practice-oriented project for assessing consequences of infrastructure projects and changes in land-use</li> </ul>
<b>Literature</b>	Lohse, Dieter und Schnabel, Werner (2011): Grundlagen der Straßenverkehrstechnik und der Verkehrsplanung – Band 2. 3. Auflage. Beuth.  Ortúzar, Juan de Dios und Willumsen, Luis G. (2011): Modelling Transport. 4. Auflage. John Wiley & Sons.

Module M0801: Water Resources and -Supply				
Courses				
Title	Typ	Hrs/wk	CP	
Chemistry of Drinking Water Treatment (L0311)	Lecture	2	1	
Chemistry of Drinking Water Treatment (L0312)	Recitation Section (large)	1	2	
Water Resource Management (L0402)	Lecture	2	2	
Water Resource Management (L0403)	Recitation Section (small)	1	1	
<b>Module Responsible</b>	Prof. Mathias Ernst			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Knowledge of water management and the key processes involved in water treatment.			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.			
<i>Skills</i>	Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.			
<i>Autonomy</i>	Students will be in a position to work on a subject independently and present on this subject.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	60 min (chemistry) + presentation			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: 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: Elective Compulsory			

Course L0311: Chemistry of Drinking Water Treatment	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The topic of this course is water chemistry with respect to drinking water treatment and water distribution</p> <p>Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards).</p> <p>Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework.</p> <p>Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course "Water resources management" in the beginning of the semester.</p>
<b>Literature</b>	<p><b>MHW (rev. by Crittenden, J. et al.):</b> Water treatment principles and design. John Wiley &amp; Sons, Hoboken, 2005.</p> <p><b>Stumm, W., Morgan, J.J.:</b> Aquatic chemistry. John Wiley &amp; Sons, New York, 1996.</p> <p><b>DVGW (Hrsg.):</b> Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.</p> <p><b>Jensen, J. N.:</b> A Problem Solving Approach to Aquatic Chemistry. John Wiley &amp; Sons, Inc., New York, 2003.</p>

Course L0312: Chemistry of Drinking Water Treatment	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L0402: Water Resource Management	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Mathias Ernst
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The lecture provides comprehensive knowledge on interaction of water resource management and drinking water supply. Content overview:</p> <ul style="list-style-type: none"> <li>• Current situation of global water resources</li> <li>- User and Stakeholder conflicts</li> <li>- Wasserressourcenmanagement in urbane Gebieten</li> <li>- Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen.</li> <li>- Ökobilanzierung, Benchmarking in der Wasserversorgung</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Aktuelle UN World Water Development Reports</li> <li>• Branchenbild der deutschen Wasserwirtschaft, VKU (2011)</li> <li>• Aktuelle Artikel wissenschaftlicher Zeitschriften</li> <li>• Ppt der Vorlesung</li> </ul>

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<b>Course L0403: Water Resource Management</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Mathias Ernst
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

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	
<b>Module Responsible</b>	Prof. Mathias Ernst			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge of water chemistry. Knowledge of the core processes involved in water, gas and steam treatment			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> 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.</p> <p><i>Autonomy</i> 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.</p>			
<b>Workload in Hours</b>				
<b>Credit points</b>				
<b>Course achievement</b>				
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	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 General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Mathias Ernst
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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 electrodialysis, 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.</p> <p>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.</p> <p>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.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage), Springer-Verlag, Berlin 2004.</li> <li>• Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands</li> <li>• Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley &amp; Sons, Ltd., 2004</li> </ul>

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

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

Module M0822: Process Modeling in Water Technology			
Courses			
Title	Typ	Hrs/wk	CP
Process Modelling of Wastewater Treatment (L0522)	Project-/problem-based Learning	2	3
Process Modeling in Drinking Water Treatment (L0314)	Project-/problem-based Learning	2	3
<b>Module Responsible</b>	Dr. Klaus Johannsen		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Knowledge of the most important processes in drinking water and waste water treatment.		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p>		
<b>Personal Competence</b>	<p><i>Social Competence</i> 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.</p> <p><i>Autonomy</i> Students are able to define a problem, gain the required knowledge and set up a model.</p>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: 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		

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

<b>Course L0314: Process Modeling in Drinking Water Treatment</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>In the beginning of the course the use of OpenModelica is explained 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.</p>
<b>Literature</b>	<p><b>OpenModelica:</b> <a href="https://openmodelica.org/index.php/download/download-windows">https://openmodelica.org/index.php/download/download-windows</a></p> <p><b>OpenModelica - Modelica Tutorial:</b> <a href="https://openmodelica.org/index.php/useresresources/userdocumentation">https://openmodelica.org/index.php/useresresources/userdocumentation</a></p> <p><b>OpenModelica - Users Guide:</b> <a href="https://openmodelica.org/index.php/useresresources/userdocumentation">https://openmodelica.org/index.php/useresresources/userdocumentation</a></p> <p><b>Peter Fritzson:</b> Principles of Object-Oriented Modeling and Simulation with Modelica 2.1, Wiley-IEEE Press, ISBN 0-471-471631.</p> <p><b>MHW (rev. by Crittenden, J. et al.):</b> Water treatment principles and design. John Wiley &amp; Sons, Hoboken, 2005.</p> <p><b>Stumm, W., Morgan, J.J.:</b> Aquatic chemistry. John Wiley &amp; Sons, New York, 1996.</p> <p><b>DVGW (Hrsg.):</b> Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.</p>

Module M0981: Operation of Public Transportation Systems			
Courses			
Title	Typ	Hrs/wk	CP
Operation of Public Transportation Systems (L1179)	Project-/problem-based Learning	4	6
<b>Module Responsible</b>	Prof. Carsten Gertz		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	Students are able to: <ul style="list-style-type: none"> <li>• describe public transport (PT) systems in technical language.</li> <li>• outline the entire PT system including the interdependencies of the different elements.</li> <li>• explain the requirements for a PT system from different perspectives.</li> <li>• explain the role of PT in the transport system.</li> </ul>		
<i>Skills</i>	Students are able to: <ul style="list-style-type: none"> <li>• systematically develop a public transport system when there are no clear cut correct or incorrect approaches.</li> <li>• cope with imprecise and incomplete data.</li> <li>• develop and appraise alternative solutions.</li> <li>• distinguish or develop appropriate methods of analysis and modes of presentation.</li> <li>• reflect and evaluate their own transport concept, considering competing requirements.</li> </ul>		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students are able to: <ul style="list-style-type: none"> <li>• carry out and complete a group project, inclusive of an appropriate allocation of tasks.</li> <li>• constructively provide and accept feedback.</li> <li>• present their own results to others.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• independently develop a bus PT concept within a given framework.</li> <li>• determine and justify the focus of their work.</li> <li>• organize and follow their work process regarding time and content.</li> <li>• independently author a written report.</li> <li>• assess the consequences of the solutions they develop.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	written assignment as groupwork with presentation during the semester		
<b>Assignment for the Following Curricula</b>	Logistics, Infrastructure and Mobility: Core Qualification: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory		

<b>Course L1179: Operation of Public Transportation Systems</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Carsten Gertz
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The course primarily deals with the planning and operational challenges of public transport systems. A bus-system is the example for studying these problems in depth. The following topics and systemic elements are covered:</p> <ul style="list-style-type: none"> <li>• PT network planning</li> <li>• timetabling</li> <li>• operational concepts</li> <li>• requirements for vehicle technology and operation</li> <li>• infrastructural requirements</li> <li>• inter- and multimodal connections</li> <li>• financing and competition</li> <li>• organisational structures</li> </ul> <p>The topics are discussed with guests lecturers from the public transport sector and are considered in practice during an excursion.</p>
<b>Literature</b>	<p>Verband Deutscher Verkehrsunternehmen / VDV-Förderkreis (Hrsg.) (2010) Nachhaltiger Nahverkehr. Köln. (2 Bände)</p> <p>Wuppertal Institut (2009) Handbuch zur Planung flexibler Bedienungsformen im ÖPNV : ein Beitrag zur Sicherung der Daseinsvorsorge in nachfrageschwachen Räumen. Bundesministerium für Verkehr, Bau und Stadtentwicklung / Bundesinstitut für Bau-, Stadt- und Raumforschung. Bonn.</p> <p>Forschungsgesellschaft für Straßen- und Verkehrswesen (2009) HVÖ - Hinweise für den Entwurf von Verknüpfungsanlagen des öffentlichen Personennahverkehrs. FGSV Verlag. Köln.</p> <p>Kirchhoff, Peter (2002) Städtische Verkehrsplanung - Konzepte, Verfahren, Maßnahmen. Vieweg+Teubner Verlag. Wiesbaden.</p> <p>Kirchhoff, Peter &amp; Tsakarestos, Antonius (2007) Planung des ÖPNV in ländlichen Räumen, Ziele - Entwurf- Realisierung. Vieweg+Teubner Verlag. Wiesbaden</p> <p>Forschungsgesellschaft für Straßen- und Verkehrswesen (2008) RIN - Richtlinien für integrierte Netzgestaltung. FGSV-Verlag. Köln.</p> <p>Forschungsgesellschaft für Straßen- und Verkehrswesen (2013) EAÖ - Empfehlungen für die Anlagen des öffentlichen Personennahverkehrs. FGSV-Verlag. Köln.</p>

Module M1505: Adaptation to Climate Change in Hydraulic Engineering (AKWAS)			
Courses			
Title	Typ	Hrs/wk	CP
Adaptation to climate change in hydraulic engineering (L2291)	Project-/problem-based Learning	4	6
<b>Module Responsible</b>	Prof. Peter Fröhle		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Hydrology, Hydraulic Engineering</li> <li>• Hydromechanic, Hydraulics</li> <li>• Fundamentals of Coastal Engineering, Coastal- and Flood Protection</li> <li>• Hydrological Systems</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>• Climate protection and climate adaptation</li> <li>• Insights into climate change and its regional characteristics - fundamentals, climate modelling / climate models</li> <li>• Impacts of climate change on the components of the regional hydrological cycle</li> <li>• Fundamentals of analysis of climate data</li> <li>• Consequences of the impact of the climate change</li> <li>• Measures for climate adaptation</li> <li>• Assessment, prioritization and communication of adaptation measures</li> <li>• Fundamentals of the analysis of hydrometeorological and hydrological data</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>• Critical thinking: analysis of processes and relations, assessment of needs for action</li> <li>• Creative thinking: development of adaptation strategies and adaptation measures</li> <li>• Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods</li> <li>• Consideration of complex tasks</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Working in heterogenous groups</li> <li>• Working with different scientific / non-scientific disciplines</li> <li>• Self reflection</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Application oriented use of knowledge and skills</li> <li>• Autonomous work on complex tasks</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	Preparation of a written report and a presentation of a complex task.		
<b>Assignment for the Following Curricula</b>	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 Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory		

<b>Course L2291: Adaptation to climate change in hydraulic engineering</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Peter Fröhle
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Climate protection and climate adaptation</li> <li>• Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models</li> <li>• Impacts of climate change on the components of the regional hydrological cycle(climate science view)</li> <li>• Fundamentals of the analysis of climate data</li> <li>• Consequences of the impacts of climate change (ingenieering science view)</li> <li>• Measures for climate change adaptation</li> <li>• Assessment, prioritization and communication of measures</li> <li>• Fundamentals of analysis of hydrometeorological and hydrological data</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Wird bereitgestellt über die HOOU - eLearning Plattform</li> <li>• abhängig von den jeweils schwerpunktmäßig behandelten Fragestellungen wird das Schrifttum (aktuelle Paper) in der Veranstaltung bzw. über StudIP zur Verfügung gestellt.</li> </ul>

**Module M1123: Selected Topics in Environmental Engineering**

Courses			
Title	Typ	Hrs/wk	CP
Environmental Aquatic Chemistry (L1444)	Lecture	2	3
Solid Matter Process Technology for Biomass (L0052)	Lecture	2	3
Sustainable landfill design and operation (L3270)	Integrated Lecture	3	3
Sludge Treatment (L0520)	Lecture	2	3
Special topics of the Environmental engineering 1CP (L3289)		1	1
Special topics of the Environmental engineering 2CP (L3290)		2	2
Special topics of the Environmental engineering 3CP (L3291)		3	3
Thermal Biomass Utilization (L1767)	Lecture	2	2
Thermal Biomass Utilization (L2386)	Practical Course	1	1
<b>Module Responsible</b>	Prof. Mathias Ernst		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i>			
<b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>			
<b>Workload in Hours</b>	Depends on choice of courses		
<b>Credit points</b>	6		
<b>Assignment for the Following Curricula</b>	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**

<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Concentration and activity</li> <li>• Gas-water partitioning</li> <li>• Acid/base equilibria</li> <li>• Alkalinity and acidity</li> <li>• Precipitation/dissolution equilibria</li> <li>• Redox equilibria</li> <li>• Complex formation</li> <li>• Sorption</li> </ul>
<b>Literature</b>	Worch, E.: Hydrochemistry. Basic Concepts and Exercises. De Gruyter, Berlin, 2015

Course L0052: Solid Matter Process Technology for Biomass	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Werner Sitzmann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture.
<b>Literature</b>	Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamasse, Springer Verlag, 2001, ISBN 3-540-64853-4  Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe, Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de  Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175

Course L3270: Sustainable landfill design and operation	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Dr. Marco Ritzkowski
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	The course introduces the development of modern waste resource management and demonstrates the importance of landfills in the context of recycling processes. Based on international (EU) and national legislation, the current landfill situation is presented and the future significance of landfills will be discussed. A central element of the course deals with the main transformation processes in the landfilled waste, the emission of gases and leachate, the long-term behaviour of landfills as well as aftercare and after-utilisation measures. Further focal points of the course are measures for the sustainable reduction of environmentally and climate-damaging emissions and aspects of landfill technology in an international context.
<b>Literature</b>	1) <b>Waste Management.</b> Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305  2) <b>Solid Waste Technology and Management.</b> Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332  3) <b>Solid Waste Landfilling - Concepts, Processes, Technologies.</b> Cossu, R. and Stegmann, R. (Eds.), ISBN: 978-0-12-818336-6  PDF (Volltext) über TUB

Course L0520: Sludge Treatment	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Dr. Joachim Behrendt
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	<b>Tchobanoglous, George</b> (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 <b>Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes</b> Sludge Treatment and Disposal ISBN 9781843391661 IWA Publishing, 2007

Course L3289: Special topics of the Environmental engineering 1CP	
<b>Typ</b>	
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Fachtheoretisch-fachpraktische Arbeit
<b>Examination duration and scale</b>	wird zu Beginn der Veranstaltung festgelegt
<b>Lecturer</b>	Dozenten des SD B
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	The course occurs only if required. The content is defined at short notice.
<b>Literature</b>	Die Literatur wird kurzfristig festgelegt.

Course L3290: Special topics of the Environmental engineering 2CP	
<b>Typ</b>	
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Fachtheoretisch-fachpraktische Arbeit
<b>Examination duration and scale</b>	wird zu Beginn der Veranstaltung festgelegt
<b>Lecturer</b>	Dozenten des SD B
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	The course occurs only if required. The content is defined at short notice.
<b>Literature</b>	Die Literatur wird kurzfristig festgelegt.

Course L3291: Special topics of the Environmental engineering 3CP	
<b>Typ</b>	
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Fachtheoretisch-fachpraktische Arbeit
<b>Examination duration and scale</b>	wird zu Beginn der Veranstaltung festgelegt
<b>Lecturer</b>	Dozenten des SD B
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	The course occurs only if required. The content is defined at short notice.
<b>Literature</b>	Die Literatur wird kurzfristig festgelegt.

Course L1767: Thermal Biomass Utilization	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Martin Kaltschmitt
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>The course is structured as follows:</p> <ul style="list-style-type: none"> <li>• Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course</li> <li>• Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste</li> <li>• Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying</li> <li>• Thermo-chemical conversion of solid biofuels <ul style="list-style-type: none"> <li>◦ Basics of thermo-chemical conversion</li> <li>◦ 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</li> <li>◦ Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels</li> <li>◦ 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</li> </ul> </li> <li>• 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)</li> <li>• Bio-chemical conversion of biomass <ul style="list-style-type: none"> <li>◦ Basics of bio-chemical conversion</li> <li>◦ 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</li> <li>◦ Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage</li> </ul> </li> </ul>
<b>Literature</b>	<b>Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage</b>

<b>Course L2386: Thermal Biomass Utilization</b>	
<b>Typ</b>	Practical Course
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Schriftliche Ausarbeitung
<b>Examination duration and scale</b>	Protokolle
<b>Lecturer</b>	Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>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.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- Kaltschmitt, Martin; Hartmann, Hans; Hofbauer, Hermann: Energie aus Biomasse: Grundlagen, Techniken und Verfahren. 3. Auflage. Berlin Heidelberg: Springer Science &amp; Business Media, 2016. -ISBN 978-3-662-47437-2</li> <li>- Versuchsskript</li> </ul>

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	
<b>Module Responsible</b>	Prof. Nima Shokri			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge on water, soil and environmental research.			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	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.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.			
<i>Autonomy</i>	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.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	Report and Presentation			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Seminar
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Salome Shokri-Kuehni
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Introduction - course objectives, expectations and format</p> <p>Analyzing the Audience, purpose and occasion</p> <p>Constructing and delivering effective technical presentations</p> <p>How to write an abstract</p> <p>How to write a scientific paper</p> <p>Developing competitive and persuasive research proposals</p> <p>Databases and resources available for water and environmental research</p> <p>Individual proposal on water and environmental research</p> <p>Individual project on water and environmental research</p> <p>Presentation on water and environmental research</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9</li> <li>• Supplemental materials and web links which will be available to registered students.</li> </ul>

Course L2750: Microplastics in Environment	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Nima Shokri
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- Introduction, objectives, expectations, format, importance</li> <li>- Sources of microplastics in environment</li> <li>- Microplastics sampling; Characterization of microplastics</li> <li>- Distribution of microplastics in terrestrial environments</li> <li>- Fate of microplastics in terrestrial environments</li> <li>- Project discussion</li> <li>- Effects of microplastics on terrestrial environments</li> <li>- Health risks of microplastics in environments</li> <li>- Project presentations by all students</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- Microplastics in Terrestrial Environments (2021), Edited by Defu He and Yongming Luo</li> <li>- Particulate Plastics in Terrestrial and Aquatic Environments (2020), Edited by Nanthi S. Bolan et al.</li> <li>- Microplastic Pollutants (2017), by Christopher B. Crawford and Brian Quinn</li> </ul>

<b>Course L2751: Scientific Communication and Methods</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Nima Shokri
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Introduction - course objectives, expectations and format</p> <p>Analyzing the Audience, purpose and occasion</p> <p>Constructing and delivering effective technical presentations</p> <p>How to write an abstract</p> <p>How to create a scientific poster</p> <p>How to write a scientific paper</p> <p>Developing competitive and persuasive research proposals</p> <p>Individual project (report and presentation) related to soil, water and environmental research</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9</li> <li>• Supplemental materials and web links which will be available to registered students.</li> </ul>

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	
<b>Module Responsible</b>	Prof. Peter Fröhle			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Hydraulic Engineering</li> <li>Hydromechanics, Hydraulics</li> <li>Fundamentals of Coastal Engineering, Coastal- and Flood Protection</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Climate and Climate Change</li> <li>General Impacts of Climate Change on Wind Regime and Water Cycle</li> <li>Consequences of Climate Change for Coastal Processes</li> <li>Coastal Protection in Taiwan and Germany</li> <li>Fundamentals of Climate Adaptation</li> <li>Nature-based Solutions (NBS) for Coastal Protection</li> </ul>			
<i>Skills</i>	<ul style="list-style-type: none"> <li>Critical thinking: analysis of processes and relations, assessment of needs for action</li> <li>Creative thinking: development of adaptation strategies and adaptation measures</li> <li>Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods</li> <li>Consideration of complex tasks</li> </ul>			
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Working in heterogenous groups</li> <li>Working in international groups</li> <li>Working with different scientific / non-scientific disciplines</li> <li>Self reflection</li> </ul>			
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>Application oriented use of knowledge and skills</li> <li>Autonomous work on complex tasks</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written elaboration			
<b>Examination duration and scale</b>	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.			
<b>Assignment for the Following Curricula</b>	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			

<b>Course L2926: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Peter Fröhle, Prof. Frank Thorenz
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Climate and Climate Change</li> <li>• General Impacts of Climate Change on Wind Regime and Water Cycle</li> <li>• Consequences of Climate Change for Coastal Processes</li> <li>• Coastal Protection in Taiwan and Germany</li> <li>• Fundamentals of Climate Adaptation</li> <li>• Nature-Based Solutions (NBS) for Coastal Protection</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Materials provided on eLearning Platform (HOOU Platform)</li> <li>• 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.</li> </ul>

Module M2003: Biological Waste Treatment				
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	
<b>Module Responsible</b>	Prof. Kerstin Kuchta			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	chemical and biological basics			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	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.			
<b>Personal Competence</b>				
<i>Social Competence</i>	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.			
<i>Autonomy</i>	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.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	None	Subject	theoretical and practical work
<b>Examination</b>	Presentation			
<b>Examination duration and scale</b>	Elaboration and Presentation (15-25 minutes in groups)			
<b>Assignment for the Following Curricula</b>	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 Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical and Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical and Bioprocess Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Process Engineering: Specialisation Environmental Process 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	
<b>Typ</b>	Practical Course
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation.</p> <p>Experiments are e.g.</p> <p>Screening and particle size determination</p> <p>Fos/Tac</p> <p>AAS</p> <p>Chalorific value</p>
<b>Literature</b>	Scripte

Course L0318: Biological Waste Treatment	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. biological basics</li> <li>3. determination process specific material characterization</li> <li>4. aerobic degradation ( Composting, stabilization)</li> <li>5. anaerobic degradation (Biogas production, fermentation)</li> <li>6. Technical layout and process design</li> <li>7. Flue gas treatment</li> <li>8. Plant design practical phase</li> </ol>
<b>Literature</b>	

Module M2009: Study Work Specialisation Cities	
Courses	
Title	Typ Hrs/wk CP
<b>Module Responsible</b>	Dozenten des SD B
<b>Admission Requirements</b>	None
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Basics of Urban Planning</li> <li>• Urban Infrastructures (Water, Energy, Heat)</li> <li>• Environmental Technologies (Solid Waste Disposal, Air Quality Control, Wastewater Treatment, etc.)</li> </ul>
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b> <i>Knowledge</i>  <i>Skills</i>  <b>Personal Competence</b> <i>Social Competence</i>  <i>Autonomy</i>	<p>The students are able to demonstrate their detailed knowledge in the field of Water and Environmental Engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society.</p> <p>The students can develop solving strategies and approaches for fundamental and practical problems in the field of Water and Environmental Engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society.</p> <p>Scientific work techniques that are used can be described and critically reviewed.</p> <p>The students are able to independently select methods or planning approaches for the project work and to justify their choice. They can explain how these methods or approaches relate to solutions in the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.</p> <p>The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.</p> <p>The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.</p>
<b>Workload in Hours</b>	Independent Study Time 360, Study Time in Lecture 0
<b>Credit points</b>	12
<b>Course achievement</b>	None
<b>Examination</b>	Study work
<b>Examination duration and scale</b>	
<b>Assignment for the Following Curricula</b>	Water and Environmental Engineering: Specialisation Cities: Compulsory

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	
<b>Module Responsible</b>	Prof. Kerstin Kuchta			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Basics of thermo dynamics</li> <li>Basics of fluid dynamics</li> <li>fluid dynamics chemistry</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p>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 .</p> <p>Students will be able to design and design waste treatment technology equipment.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students can</p> <ul style="list-style-type: none"> <li>respectfully work together as a team and discuss technical tasks</li> <li>participate in subject-specific and interdisciplinary discussions,</li> <li>develop cooperated solutions</li> <li>promote the scientific development and accept professional constructive criticism.</li> </ul> <p><i>Autonomy</i> 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.</p>			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	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 Chemical and Bioprocess Engineering: Specialisation Chemical and Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical and Bioprocess 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	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Rüdiger Siechau
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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).</p> <p>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.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010</li> <li>• PowerPoint Präsentationen in Stud IP</li> </ul>

Course L3265: Recycling technologies and thermal waste treatment	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction, actual state-of-the-art of waste incineration, aims. legal background, reaction principals</li> <li>• basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition</li> <li>• Incineration techniques: grate firing, ash transfer, boiler</li> <li>• Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination</li> <li>• Ash treatment: Mass, quality, treatment concepts, recycling, disposal</li> </ul>
<b>Literature</b>	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	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M2076: Introduction to Climate Informed Engineering				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Methods in Climate Informed Engineering (L3347)		Lecture	3	3
Topics in Climate Informed Engineering (L3348)		Lecture	3	3
<b>Module Responsible</b>	Prof. Nima Shokri			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Students are expected to have a foundational understanding of environmental science, basic engineering principles, and an interest in sustainability. Recommended knowledge includes climate science, data analysis, and familiarity with engineering design processes. Analytical and critical thinking and creative problem-solving skills are also beneficial			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	This module explores next-generation climate models and high-resolution data, emphasizing their impact on environmental and engineering products and processes. It covers how various engineering disciplines can benefit from climate information. Research-based learning activities, expert talks, and presentations will expose students to state-of-the-art modeling, measurement, and analysis in climate-informed engineering.			
<i>Skills</i>	Climate data analysis, engineering adaptation strategies, problem-solving, research-based learning, and interdisciplinary collaboration.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Collaboration, interdisciplinary teamwork, communication skills, problem-solving, ethical responsibility, and decision-making in climate-resilient engineering.			
<i>Autonomy</i>	Time management, self-directed learning, critical thinking, accountability, initiative, and the ability to conduct independent research and make informed decisions in climate-informed engineering.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	Report and Presentation			
<b>Assignment for the Following Curricula</b>	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 Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Data Science: Specialisation III. Applications: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Process Engineering: Specialisation Process Engineering: 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 L3347: Methods in Climate Informed Engineering	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Nima Shokri, Prof. Cathy Hohenegger, Prof. Irina Smirnova
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	Students will learn techniques for incorporating climate data and environmental factors into engineering design. It covers climate modelling and the use of sensors and devices to measure climate-related parameters and engineering processes. Students will have the opportunity to conduct their own measurements, analyze the collected data, and write a report on their findings. This hands-on experience will be assessed and contribute to their final grade.
<b>Literature</b>	

<b>Course L3348: Topics in Climate Informed Engineering</b>	
<b>Type</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Irina Smirnova, Prof. Cathy Hohenegger, Prof. Nima Shokri
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	Exploring specific applications of climate data in various engineering disciplines. Invited speakers will present their research and discuss the relevance of climate-informed engineering to their work. Additionally, there will be a segment on effective communication, covering how to give impactful presentations and write research papers. Students will also give presentations on their own class projects related to climate-informed engineering, applying the concepts they've learned. This hands-on experience will be assessed and contribute to their final grade.
<b>Literature</b>	

Module M2156: Water Protection				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Water Protection (L3459)		Integrated Lecture	6	6
<b>Module Responsible</b>	Prof. Simon Michael Papalexiou			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Basic knowledge in water management;</li> <li>• Good knowledge in urban drainage;</li> <li>• Good knowledge of wastewater treatment techniques;</li> <li>• Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties;</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	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.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students can work together in international groups.			
<i>Autonomy</i>	Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	20 %	Presentation	10-minütige Präsentation von Arbeitsergebnissen
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	150 minutes			
<b>Assignment for the Following Curricula</b>	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 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 Environment: Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory			

Course L3459: Water Protection	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	6
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
<b>Lecturer</b>	Prof. Simon Michael Papalexiou
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	
<b>Literature</b>	

<b>Module M2155: Uncertainty Modelling for Engineers</b>				
<b>Courses</b>				
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>	
Uncertainty Modelling for Engineers (L3458)	Integrated Lecture	6	6	
<b>Module Responsible</b>	Prof. Simon Michael Papalexiou			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ol style="list-style-type: none"> <li>1. General familiarity with engineering concepts.</li> <li>2. Elementary probability and statistics, and mathematical skills.</li> <li>3. Basic computer skills for handling data.</li> <li>4. Interest in solving engineering problems using statistical and probabilistic methods.</li> </ol>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students will develop a strong foundation in uncertainty, probability, and risk analysis in engineering applications. The course introduces probability as a measure of uncertainty, covering frequency-based methods. Students will explore Bayes' Theorem, probability distributions, extreme value theory, joint probability distributions, and stochastic optimization to model and quantify uncertainty in engineering problems. The course also covers linear and nonlinear regression methods, essential for data-driven decision-making and predictive modeling. Additionally, students will gain insight into risk assessment as a function of probability and disutility and learn how to apply Bayesian Decision Theory to optimize engineering solutions under uncertainty.</p> <p><i>Skills</i> By the end of the course, students will be able to apply probabilistic models to quantify uncertainty and assess risks in engineering problems. They will gain expertise in fitting probability distributions, performing extreme value analysis, and applying Bayesian inference to real-world engineering challenges. Students will also develop skills in linear and nonlinear regression modeling, enabling them to analyze complex engineering datasets and improve risk predictions. Through hands-on computational exercises, they will learn to implement stochastic methods and optimization techniques to support reliability-based design and engineering decision-making.</p>			
<b>Personal Competence</b>	<p><i>Social Competence</i> Students will develop the ability to work collaboratively on engineering risk assessments, communicating technical results effectively with peers, engineers, and decision-makers. They will engage in discussions on risk perception, safety factors, and uncertainty quantification, ensuring that engineering analyses are both rigorous and applicable to real-world infrastructure challenges.</p> <p><i>Autonomy</i> Students will learn to independently analyze and model engineering uncertainties, selecting and applying appropriate probability distributions, regression methods, and stochastic techniques for various applications. They will also gain the ability to evaluate risks associated with natural and human-made hazards, ensuring they can make informed engineering decisions in design, safety assessment, and disaster mitigation.</p>			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	20 %	Presentation	10-minütige Präsentation von Arbeitsergebnissen
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	150 min			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory 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 Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory			

<b>Course L3458: Uncertainty Modelling for Engineers</b>	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	6
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
<b>Lecturer</b>	Prof. Simon Michael Papalexiou
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Engineering decisions are rarely made with complete certainty—uncertainty affects material properties, environmental conditions, structural performance, and risk assessments. This course provides students with theoretical foundations and practical tools to quantify uncertainty, assess risks, and enhance decision-making in civil, structural, geotechnical, and environmental engineering applications. Students will begin with fundamental probability concepts, learning how Bayes' Theorem, probability distributions, and extreme value theory help evaluate engineering uncertainties. They will explore linear and nonlinear regression methods for analyzing complex datasets, as well as joint probability distributions and stochastic optimization to improve predictive modeling and reliability assessments. The course also introduces Bayesian Decision Theory, offering a structured approach to decision-making under uncertainty. With a focus on real-world engineering problems, students will apply probabilistic models, extreme value analysis, and stochastic techniques to assess risks in infrastructure design, system reliability, and disaster resilience. Hands-on computational exercises will reinforce key concepts, preparing students to work with data-driven models and uncertainty quantification techniques used in engineering practice. This course is ideal for students interested in engineering risk assessment, reliability analysis, and data-driven modeling. By the end of the course, students will have developed critical analytical and problem-solving skills, equipping them for careers in structural safety, geotechnical engineering, environmental risk management, and beyond.</p>
<b>Literature</b>	

## Specialization Environment

### 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
<b>Module Responsible</b>	Prof. Ralf Otterpohl		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Basic knowledge in water management;</li> <li>• Good knowledge in urban drainage;</li> <li>• Good knowledge of wastewater treatment techniques;</li> <li>• Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties;</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p>		
<b>Personal Competence</b>	<p><i>Social Competence</i> The students can work together in international groups.</p> <p><i>Autonomy</i> Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently.</p>		
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Presentation		
<b>Examination duration and scale</b>	Term paper plus presentation		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Ralf Otterpohl
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The lecture focusses on:</p> <ul style="list-style-type: none"> <li>• Regulatory Framework (e.g. WFD)</li> <li>• Main instruments for the water management and protection</li> <li>• In depth knowledge of relevant measures of water pollution control</li> <li>• Urban drainage, treatment options in different regions on the world</li> <li>• Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration</li> <li>• Case Studies and Field Trips</li> </ul>
<b>Literature</b>	<p>The literature listed below is available in the library of the TUHH.</p> <ul style="list-style-type: none"> <li>• Water and wastewater technology Hammer, M. J. 1., &amp; . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International.</li> <li>• Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill.</li> <li>• Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ.</li> </ul>

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

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	
<b>Module Responsible</b>	Prof. Kerstin Kuchta			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Basics of thermo dynamics</li> <li>Basics of fluid dynamics</li> <li>fluid dynamics chemistry</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p>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 .</p> <p>Students will be able to design and design waste treatment technology equipment.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students can</p> <ul style="list-style-type: none"> <li>respectfully work together as a team and discuss technical tasks</li> <li>participate in subject-specific and interdisciplinary discussions,</li> <li>develop cooperated solutions</li> <li>promote the scientific development and accept professional constructive criticism.</li> </ul> <p><i>Autonomy</i> 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.</p>			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	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 Chemical and Bioprocess Engineering: Specialisation Chemical and Bio 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	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Rüdiger Siechau
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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).</p> <p>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.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010</li> <li>• PowerPoint Präsentationen in Stud IP</li> </ul>

Course L3265: Recycling technologies and thermal waste treatment	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction, actual state-of-the-art of waste incineration, aims. legal background, reaction principals</li> <li>• basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition</li> <li>• Incineration techniques: grate firing, ash transfer, boiler</li> <li>• Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination</li> <li>• Ash treatment: Mass, quality, treatment concepts, recycling, disposal</li> </ul>
<b>Literature</b>	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	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0513: System Aspects of Renewable Energies				
<b>Courses</b>				
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>	
Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021)	Lecture	2	2	
Energy Trading (L0019)	Lecture	1	1	
Energy Trading (L0020)	Recitation Section (small)	1	1	
Deep Geothermal Energy (L0025)	Lecture	2	2	
<b>Module Responsible</b>	Prof. Martin Kaltschmitt			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Module: Technical Thermodynamics I Module: Technical Thermodynamics II			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students are able to describe the processes in energy trading and the design of energy markets and can critically evaluate them in relation to current subject specific problems. Furthermore, they are able to explain the basics of thermodynamics of electrochemical energy conversion in fuel cells and can establish and explain the relationship to different types of fuel cells and their respective structure. Students can compare this technology with other energy storage options. In addition, students can give an overview of the procedure and the energetic involvement of deep geothermal energy.</p> <p><i>Skills</i> Students can apply the learned knowledge of storage systems for excessive energy to explain for various energy systems different approaches to ensure a secure energy supply. In particular, they can plan and calculate domestic, commercial and industrial heating equipment using energy storage systems in an energy-efficient way and can assess them in relation to complex power systems. In this context, students can assess the potential and limits of geothermal power plants and explain their operating mode.</p> <p>Furthermore, the students are able to explain the procedures and strategies for marketing of energy and apply it in the context of other modules on renewable energy projects. In this context they can unassistedly carry out analysis and evaluations of energie markets and energy trades.</p>			
<b>Personal Competence</b>				
<i>Social Competence</i>				
<i>Autonomy</i>	Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module.			
<i>Autonomy</i>	Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	3 hours written exam			
<b>Assignment for the Following Curricula</b>	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: 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			

Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Michael Fröba
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction to electrochemical energy conversion</li> <li>2. Function and structure of electrolyte</li> <li>3. Low-temperature fuel cell                             <ul style="list-style-type: none"> <li>◦ Types</li> <li>◦ Thermodynamics of the PEM fuel cell</li> <li>◦ Cooling and humidification strategy</li> </ul> </li> <li>4. High-temperature fuel cell                             <ul style="list-style-type: none"> <li>◦ The MCFC</li> <li>◦ The SOFC</li> <li>◦ Integration Strategies and partial reforming</li> </ul> </li> <li>5. Fuels                             <ul style="list-style-type: none"> <li>◦ Supply of fuel</li> <li>◦ Reforming of natural gas and biogas</li> <li>◦ Reforming of liquid hydrocarbons</li> </ul> </li> <li>6. Energetic Integration and control of fuel cell systems</li> </ol>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003</li> </ul>

Course L0019: Energy Trading	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Robert Gersdorf
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Basic concepts and tradable products in energy markets</li> <li>• Primary energy markets</li> <li>• Electricity Markets</li> <li>• European Emissions Trading Scheme</li> <li>• Influence of renewable energy</li> <li>• Real options</li> <li>• Risk management</li> </ul> <p>Within the exercise the various tasks are actively discussed and applied to various cases of application.</p>
<b>Literature</b>	

Course L0020: Energy Trading	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Robert Gersdorf
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

<b>Course L0025: Deep Geothermal Energy</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Ben Norden
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction to the deep geothermal use</li> <li>2. Geological Basics I</li> <li>3. Geological Basics II</li> <li>4. Geology and thermal aspects</li> <li>5. Rock Physical Aspects</li> <li>6. Geochemical aspects</li> <li>7. Exploration of deep geothermal reservoirs</li> <li>8. Drilling technologies, piping and expansion</li> <li>9. Borehole Geophysics</li> <li>10. Underground system characterization and reservoir engineering</li> <li>11. Microbiology and Upper-day system components</li> <li>12. Adapted investment concepts, cost and environmental aspect</li> </ol>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Dipippo, R.: Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact. Butterworth Heinemann; 3rd revised edition. (29. Mai 2012)</li> <li>• <a href="http://www.geo-energy.org">www.geo-energy.org</a></li> <li>• Edenhofer et al. (eds): Renewable Energy Sources and Climate Change Mitigation; Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2012.</li> <li>• Kaltschmitt et al. (eds): Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer, 5. Aufl. 2013.</li> <li>• Kaltschmitt et al. (eds): Energie aus Erdwärme. Spektrum Akademischer Verlag; Auflage: 1999 (3. September 2001)</li> <li>• Huenges, E. (ed.): Geothermal Energy Systems: Exploration, Development, and Utilization. Wiley-VCH Verlag GmbH &amp; Co. KGaA; Auflage: 1. Auflage (19. April 2010)</li> </ul>

**Module M0827: Modeling in Water Management**

**Courses**

Title	Typ	Hrs/wk	CP
Groundwater Modeling using Modflow (L0543)	Lecture	1	1
Groundwater Modeling using Modflow (L0544)	Recitation Section (small)	2	2
Modeling of Water Supply Network (L0875)	Project-/problem-based Learning	2	3

<b>Module Responsible</b>	Dr. Klaus Johannsen
<b>Admission Requirements</b>	None
<b>Recommended Previous Knowledge</b>	<p>Groundwater</p> <ul style="list-style-type: none"> <li>groundwater hydraulics and transport of substances</li> </ul> <p>Pipe Systems</p> <ul style="list-style-type: none"> <li>Knowledge on urban water infrastructures, in particular drinking water systems and urban drainage systems including special structures</li> <li>Hydraulics of drinking water supply systems and sewer systems</li> <li>Basic knowledge on water management</li> </ul>
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	<p><i>Knowledge</i> The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.</p> <p><i>Skills</i> The students are able to construct and apply scientific groundwater models independently. They can work on different scenarios and can compare or assess different solutions for existing problems by application of selected software products. The students are able to use different software solutions (e.g. EPANET, EPA-SWMM).</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Wird nicht vermittelt.</p> <p><i>Autonomy</i> Wird nicht vermittelt.</p>
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70
<b>Credit points</b>	6
<b>Course achievement</b>	None
<b>Examination</b>	Oral exam
<b>Examination duration and scale</b>	30 min
<b>Assignment for the Following Curricula</b>	<p>Civil Engineering: Specialisation Structural Engineering: Elective Compulsory</p> <p>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory</p> <p>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory</p> <p>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory</p> <p>Civil Engineering: Specialisation Computational Engineering: Elective Compulsory</p> <p>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory</p> <p>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory</p> <p>Water and Environmental Engineering: Specialisation Water: Elective Compulsory</p>

**Course L0543: Groundwater Modeling using Modflow**

<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Sonja Götz
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical background of the model, students do work with the model PMWIN for practical case studies.
<b>Literature</b>	<p>MODFLOW-Handbuch</p> <p>Chiang, Wen Hsien: PMWIN</p>

<b>Course L0544: Groundwater Modeling using Modflow</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Sonja Götz
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

<b>Course L0875: Modeling of Water Supply Network</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014.

Module M0828: Urban Environmental Management			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Noise Protection (L1109)		Lecture	2                  2
Urban Infrastructures (L0874)		Project-/problem-based Learning	2                  4
<b>Module Responsible</b>	Dr. Dorothea Rechtenbach		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Knowledge on Urban planning</li> <li>• Knowledge on measures for climate protection</li> <li>• General knowledge of scientific writing/working</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students can work together in international groups.</p> <p><i>Autonomy</i> 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.</p>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	Written Report plus oral Presentation		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Martin Jäschke
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	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

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Course L0874: Urban Infrastructures	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Dorothea Rechtenbach
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Problem Based Learning</p> <p>Main topics are:</p> <ul style="list-style-type: none"> <li>• Central vs. Decentral Wastewater Treatment.</li> <li>• Compaction of Cities.</li> <li>• Car Free Cities.</li> <li>• Multifunctional Places in Cities.</li> <li>• The Sustainability of Freight Transport in Cities.</li> </ul>
<b>Literature</b>	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	
<b>Module Responsible</b>	Prof. Peter Fröhle			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Fundamentals of Hydromechanics, Hydraulics, Hydrology and Hydraulic Engineering; Hydraulic Engineering I and Hydraulic Engineering II			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	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.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students are able to deploy their gained knowledge in applied problems of the practical nature-based hydraulic engineering. Additionally, they will be able to work in team with engineers of other disciplines.			
<i>Autonomy</i>	The students will be able to independently extend their knowledge and apply it to new problems.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	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.			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Edgar Nehlsen, Prof. Peter Fröhle
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Introduction to numerical flow modelling</p> <ul style="list-style-type: none"> <li>• Processes affecting the flow</li> <li>• Examples and applications of numerical models</li> <li>• Procedure of numerical modelling</li> <li>• Model concept</li> </ul> <p>Basic equations of hydrodynamics</p> <ul style="list-style-type: none"> <li>• Saint-Venant equations</li> <li>• Euler Equations</li> <li>• Navier-Stokes equations</li> <li>• Reynolds-averaged Navier-Stokes equations</li> <li>• Shallow water equations</li> </ul> <p>Solving schemes</p> <ul style="list-style-type: none"> <li>• Numerical discretization</li> <li>• Solution algorithms</li> <li>• Convergence</li> </ul>
<b>Literature</b>	<p>Vorlesungsskript</p> <p>Literaturempfehlungen</p> <p>Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt).</p> <p>Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series).</p> <p>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).</p> <p>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).</p> <p>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).</p> <p>Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter <a href="http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html">http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html</a>.</p> <p>IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92.</p> <p>Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology.</p> <p>Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83).</p> <p>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).</p> <p>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).</p>

<b>Course L0961: Nature-Oriented Hydraulic Engineering / Integrated Flood Protection</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Natasa Manojlovic, Prof. Peter Fröhle
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Regime-Theory and application for the development of environmental guiding principles of rivers</li> <li>• Engineering - biological measures for the stabilization of rivers</li> <li>• Risk management in flood protection</li> <li>• Design techniques in technical flood protection</li> <li>• Methods for the assessment of flood caused damages</li> </ul>
<b>Literature</b>	Vorlesungsumdruck

Module M0874: Wastewater Systems			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Dr. Joachim Behrendt		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Knowledge of wastewater management and the key processes involved in wastewater treatment.		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	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.		
<i>Skills</i>	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.		
<b>Personal Competence</b>			
<i>Social Competence</i>	Social skills are not targeted in this module.		
<i>Autonomy</i>	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.		
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Joachim Behrendt
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Charaterisation of Wastewater Metabolism of Microorganisms Kinetic of microbiotic 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
<b>Literature</b>	<b>Gujer, Willi</b> 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](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-Pföhlen : 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](http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf) URL:  
[http://www.gbv.de/dms/weimar/abs/513989765\\_abs.pdf](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](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	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Joachim Behrendt
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

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

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

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	
<b>Module Responsible</b>	Prof. Ralf Otterpohl			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge of the global situation with rising poverty, soil degradation, migration to cities, lack of water resources and sanitation			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> Students are able to design ecological settlements for different geographic and socio-economic conditions for the main climates around the world.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students are able to develop a specific topic in a team and to work out milestones according to a given plan.</p> <p><i>Autonomy</i> Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.</p>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	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 semester in the StudIP course module handbook.			
<b>Assignment for the Following Curricula</b>	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			

<b>Course L1229: Ecological Town Design - Water, Energy, Soil and Food Nexus</b>	
<b>Typ</b>	Seminar
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Ralf Otterpohl
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Participants Workshop: Design of the most attractive productive Town</li> <li>• Keynote lecture and video</li> <li>• The limits of Urbanization / Green Cities</li> <li>• The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities</li> <li>• Global Ecovillage Network: Upsides and Downsides around the World</li> <li>• Visit of an Ecovillage</li> <li>• Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competition</li> <li>• TUHH Rural Development Toolbox</li> <li>• Integrated New Town Development</li> <li>• Participants workshop: Design of New Towns: Northern, Arid and Tropical cases</li> <li>• Outreach: Participants campaign</li> <li>• City with the Rural: Resilience, quality of live and productive biodiversity</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• 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</li> <li>• <a href="http://youtu.be/9hmkgn0nBgk">http://youtu.be/9hmkgn0nBgk</a> (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> <li>• TEDx New Town Ralf Otterpohl: <a href="http://youtu.be/_M0J2u9BrbU">http://youtu.be/_M0J2u9BrbU</a></li> </ul>

<b>Course L0939: Water &amp; Wastewater Systems in a Global Context</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Ralf Otterpohl
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Keynote lecture and video</li> <li>• Water &amp; Soil: Water availability as a consequence of healthy soils</li> <li>• Water and it's utilization, Integrated Urban Water Management</li> <li>• Water &amp; Energy, lecture and panel discussion pro and con for a specific big dam project</li> <li>• Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation</li> <li>• Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches</li> <li>• Why are there excreta in water? Public Health, Awareness Campaigns</li> <li>• Rehearsal session, Q&amp;A</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press</li> <li>• Liu, John D.: <a href="http://eempc.org/hope-in-a-changing_climate/">http://eempc.org/hope-in-a-changing_climate/</a> (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda)</li> <li>• <a href="http://youtu.be/9hmkgn0nBgk">http://youtu.be/9hmkgn0nBgk</a> (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> </ul>

Module M0922: City Planning			
Courses			
Title	Typ	Hrs/wk	CP
City Planning (L1066)	Project-/problem-based Learning	4	6
<b>Module Responsible</b>	Prof. Carsten Gertz		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	for "Principles of Urban Planning": none for "Designing Urban Streetscapes": some knowledge of transport planning, e.g. through taking the undergraduate class „Transport Planning and Traffic Engineering“		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	Students are able to: <ul style="list-style-type: none"> <li>• use technical terms of urban planning.</li> <li>• describe the main determinants of urban development.</li> <li>• explain and compare different possibilities of how urban development can be influenced.</li> <li>• discuss requirements for public streetscapes.</li> <li>• explain the importance of street design.</li> </ul>		
<i>Skills</i>	Students are able to: <ul style="list-style-type: none"> <li>• read and analyze urban development concepts and designs for streetscapes</li> <li>• appraise such concepts in the context of competing requirements.</li> <li>• design, justify and reflect their own solutions for concrete examples.</li> </ul>		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students are able to: <ul style="list-style-type: none"> <li>• discuss intermediate results with each other.</li> <li>• constructively accept feedback on their own work.</li> <li>• provide constructive feedback to others.</li> </ul>		
<i>Autonomy</i>	Students are able to: <ul style="list-style-type: none"> <li>• independently complete a written report including drawings following a broadly pre-defined process.</li> <li>• assess the consequences of their proposed solutions.</li> <li>• independently acquire knowledge and apply this to new issues or problem areas.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	written assignment, designwork during the semester		
<b>Assignment for the Following Curricula</b>	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 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		

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<b>Course L1066: City Planning</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Carsten Gertz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>„Principles of Urban Planning“ deals with the determinants of urban development and their interactions. Topics include:</p> <ul style="list-style-type: none"> <li>• legal framework,</li> <li>• instruments and methods of planning,</li> <li>• functional requirements,</li> <li>• stakeholders and actors</li> <li>• basic design requirements</li> <li>• different planning levels and</li> <li>• historical contexts.</li> </ul> <p>The objective of the course is for students to acquire a basic understanding of urban development problems and approaches for solving them. They will also be able to comprehend the process of urban planning. The course also covers the various functional and aesthetic requirements for designing streetscape as the most important elements of public space.</p> <p>The project work deals with a real life scenario and includes drawing up a development plan, an urban design concept, a building masterplan and a street redesign.</p>
<b>Literature</b>	<p>Albers, Gerd; Wekel, Julian (2021) Stadtplanung: Eine illustrierte Einführung. 4. überarbeitete Auflage. Primus Verlag. Darmstadt.</p> <p>Frick, Dieter (2011) Theorie des Städtebaus: Zur baulich-räumlichen Organisation von Stadt. 3. veränderte Auflage. Wasmuth-Verlag. Tübingen</p> <p>Jonas, Carsten (2009) Die Stadt und ihr Grundriss. Wasmuth-Verlag. Tübingen</p> <p>Kostof, Spiro; Castillo, Greg (1998) Die Anatomie der Stadt. Geschichte städtischer Strukturen. Campus-Verlag. Frankfurt/New York.</p>

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	
<b>Module Responsible</b>	Prof. Kay Smarsly			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	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.			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	The students will gain insights into operating state-of-the-art smart sensor systems, used for monitoring a wide range of physical processes relevant to engineering, such as environmental, structural, or comfort monitoring. The students will be capable of devising monitoring strategies of physical processes as part of group projects, tailored to their knowledge backgrounds, and to implement the strategies in smart wireless sensor nodes, using embedded computing and programming. Finally, the students will be able to document the findings of their projects in short reports.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students will be able to work in groups, share parts of the work for their projects, and develop communication skills, towards achieving the common project goals.			
<i>Autonomy</i>	The students will be able to gain a solid basis on approaching and solving problems in engineering, as well as on documenting results, through their involvement in their monitoring group projects.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written elaboration			
<b>Examination duration and scale</b>	10 pages of work with 15-minute oral presentation			
<b>Assignment for the Following Curricula</b>	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 Computer Science: Specialisation II: Intelligence 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 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	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kay Smarsly
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Course L2763: Smart Monitoring	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kay Smarsly
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

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

Courses			
Title	Typ	Hrs/wk	CP
Water and Environment (L2754)	Project-/problem-based Learning	3	3
Water and Environment (L2753)	Lecture	3	3
<b>Module Responsible</b>	Prof. Nima Shokri		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic knowledge in water and environmental research, Hydrology		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.</p> <p><i>Autonomy</i> 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.</p>		
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Subject theoretical and practical work		
<b>Examination duration and scale</b>	Report and Presentation		
<b>Assignment for the Following Curricula</b>	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**

<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Dr. Salome Shokri-Kuehni
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

**Course L2753: Water and Environment**

<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Nima Shokri
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	NA

Module M0858: Coastal Hydraulic Engineering I			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Basics of Coastal Engineering (L0807)	Lecture	3	4
Basics of Coastal Engineering (L1413)	Project-/problem-based Learning	1	2
<b>Module Responsible</b>	Prof. Peter Fröhle		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basics of hydraulic engineering, hydrology and hydromechanics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> The students are capable to apply basic design approaches to selected and pre-defined design tasks in coastal engineering.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students are able to deploy their gained knowledge in applied problems such as the design of coastal protection structures. Additionally, they will be able to work in team with engineers of other disciplines, for instance designing of coastal breakwaters.</p> <p><i>Autonomy</i> The students will be able to independently extend their knowledge and apply it to new problems.</p>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	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.		
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: 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		

Course L0807: Basics of Coastal Engineering	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Peter Fröhle
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Basics of planning and design               <ul style="list-style-type: none"> <li>◦ Water levels</li> <li>◦ Currents</li> <li>◦ Waves</li> <li>◦ Ice</li> </ul> </li> <li>• Planning and Design in Coastal Engineering               <ul style="list-style-type: none"> <li>◦ Functional and constructional design</li> <li>◦ Determination of design parameters</li> <li>◦ Design-approaches                   <ul style="list-style-type: none"> <li>▪ Filter</li> <li>▪ Rubble mound constructions</li> <li>▪ Piles</li> <li>▪ Vertical constructions</li> </ul> </li> </ul> </li> </ul>
<b>Literature</b>	Coastal Engineering Manual, CEM  Vorlesungsumdruck

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

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

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

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

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

Module M1878: Sustainable energy from wind and water				
Courses				
Title	Typ	Hrs/wk	CP	
Offshore Geotechnical Engineering (L0067)	Lecture	1	1	
Hydro Power Use (L0013)	Lecture	1	1	
Wind Turbine Plants (L0011)	Lecture	2	3	
Wind Energy Use - Focus Offshore (L0012)	Lecture	1	1	
<b>Module Responsible</b>	Dr. Marvin Scherzinger			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Module: Technical Thermodynamics I, Module: Technical Thermodynamics II, Module: Fundamentals of Fluid Mechanics			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe.</p> <p>Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice.</p> <p><i>Skills</i> Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students can discuss scientific tasks sujet-specificly and multidisciplinary within a seminar.</p> <p><i>Autonomy</i> Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.</p>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	180 min			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: 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 Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: 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 L0067: Offshore Geotechnical Engineering	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Jan Dührkop
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Overview and Introduction Offshore Geotechnics</li> <li>• Introduction to Soil Mechanics</li> <li>• Offshore soil investigation</li> <li>• Focus on cyclical effects</li> <li>• Geotechnical design of offshore foundations</li> <li>• Monopiles</li> <li>• Jackets</li> <li>• Heavyweight foundations</li> <li>• Geotechnical preliminary exploration for the use of lift boats and platforms</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Randolph, M. and Gourvenec, S (2011): Offshore Geotechnical Engineering. Spon Press.</li> <li>• Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London</li> <li>• BSH-Standard Baugrunderkundung für Offshore-Windenergieparks</li> <li>• Lesny K. (2010): Foundations for Offshore Wind Turbines. VGE Verlag, Essen.</li> <li>• EA-Pfähle (2012): Empfehlungen des Arbeitskreises Pfähle der DGGT. Ernst &amp; Sohn, Berlin.</li> </ul>

Course L0013: Hydro Power Use	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Stefan Achleitner
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction, importance of water power in the national and global context</li> <li>• Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies</li> <li>• Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems</li> <li>• Construction of hydroelectric power plants: description of the individual components and their technical system interaction</li> <li>• Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc.</li> <li>• Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection</li> <li>• Hydropower and the Environment</li> <li>• Examples from practice</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage</li> <li>• Quaschnig, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage</li> <li>• Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage</li> <li>• von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage</li> <li>• Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006</li> </ul>

Course L0011: Wind Turbine Plants	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Rudolf Zellermann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Historical development</li> <li>• Wind: origins, geographic and temporal distribution, locations</li> <li>• Power coefficient, rotor thrust</li> <li>• Aerodynamics of the rotor</li> <li>• Operating performance</li> <li>• Power limitation, partial load, pitch and stall control</li> <li>• Plant selection, yield prediction, economy</li> <li>• Excursion</li> </ul>
<b>Literature</b>	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005

Course L0012: Wind Energy Use - Focus Offshore	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Martin Skiba
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering</li> <li>• Physical fundamentals for utilization of wind energy</li> <li>• Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships</li> <li>• Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures</li> <li>• Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection</li> <li>• Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics</li> <li>• Development and planning of offshore wind farms</li> <li>• Operation and optimization of offshore wind farms</li> <li>• Day excursion</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage</li> <li>• Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidelberg, 1997, 3. Auflage</li> <li>• Hau, E.: Windkraftanlagen; Springer, Berlin, Heidelberg, 2008, 4. Auflage</li> <li>• Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage</li> <li>• Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage</li> </ul>

Module M0871: Hydrological Systems			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Prof. Peter Fröhle		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Fundamentals of Hydromechanics and Hydraulic Engineering: Hydraulic Engineering I and Hydraulic Engineering II		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students are able to deploy their gained knowledge in applied problems of the hydrology and water management. Additionally, they will be able to work in team with engineers of other disciplines.</p> <p><i>Autonomy</i> The students will be able to independently extend their knowledge and apply it to new problems</p>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	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.		
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory 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 Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory		

Course L0289: Applied Surface Hydrology	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Peter Fröhle
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Basics of hydrology: <ul style="list-style-type: none"> <li>• Hydrological cycle</li> <li>• Data acquisition</li> <li>• Data analyses and statistical assessment</li> <li>• Statistics of extremes</li> <li>• Regionalization methods for hydrological values</li> <li>• Rainfall-run-off modelling on the basis of a unit hydrograph concepts</li> <li>• Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool.</li> </ul>
<b>Literature</b>	<a href="http://de.wikipedia.org/wiki/Kalypso_(Software)">http://de.wikipedia.org/wiki/Kalypso_(Software)</a> <a href="http://kalypso.bjoernsen.de/">http://kalypso.bjoernsen.de/</a> <a href="http://sourceforge.net/projects/kalypso/">http://sourceforge.net/projects/kalypso/</a>

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

<b>Course L0295: Interaction Water - Environment in Fluvial Areas</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Peter Fröhle
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	-

Module M2002: Waste and Resource Management				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Waste management (L3261)		Project-/problem-based Learning	3	3
International waste concepts (L3259)		Lecture	2	2
International waste concepts (L3260)		Recitation Section (small)	1	1
<b>Module Responsible</b>	Prof. Kerstin Kuchta			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basics in process engineering			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	The students are able to describe waste as a resource as well as advanced technologies for recycling and recovery of resources from waste in detail. This covers collection, transport, treatment and disposal in national and international contexts.			
<i>Skills</i>	Students are able to select suitable processes for the treatment with respect to the national or cultural and developmental context. They can evaluate the ecological impact and the technical effort of different technologies and management systems.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students can work together as a team of 2-5 persons, 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 colleagues. Furthermore, they can give and accept professional constructive criticisms.			
<i>Autonomy</i>	Students can independently gain additional knowledge of the subject area and apply it in solving the given course tasks and projects.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	20 %	Written elaboration	
<b>Examination</b>	Presentation			
<b>Examination duration and scale</b>	PowerPoint presentation (10-15 minutes)			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Water and Traffic: 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 Chemical and Bioprocess Engineering: Specialisation Chemical and Bio process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Core Qualification: Elective Compulsory Environmental Engineering: Specialisation Energy and Resources: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory			

Course L3261: Waste management	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Rüdiger Siechau
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction into the "Waste Management" consisting of:               <ul style="list-style-type: none"> <li>◦ Thermal Process (incinerator, RDF combustion)</li> <li>◦ Biological processes (Wet-/Dryfermentation)</li> <li>◦ technology, energy, emissions, approval , etc.</li> </ul> </li> <li>• Group work               <ul style="list-style-type: none"> <li>◦ design of systems/plants for energy recovery from waste</li> <li>◦ The following points are to be processed:                   <ul style="list-style-type: none"> <li>▪ Input: waste (fraction collection and transportation, current quantity, material flows , possible amount of development)</li> <li>▪ Plant (design, process diagram, technology, energy production)</li> <li>▪ Output (energy quantity / type, by-products)</li> <li>▪ Costs and revenues</li> <li>▪ Climate and resource protection (CO2 balance , substitution of primary raw materials / fossil fuels)</li> <li>▪ Location and approval (infrastructure , expiration authorization procedure)</li> <li>▪ Focus at the whole concept (advantages, disadvantages , risks and opportunities , discussion)</li> </ul> </li> </ul> </li> </ul>
<b>Literature</b>	Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010  Powerpoint-Folien in Stud IP

Course L3259: International waste concepts	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Waste avoidance and recycling are the focus of this lecture. Additionally, waste logistics ( Collection, transport, export, fees and taxes) as well as international waste shipment solutions are presented.</p> <p>Other specific wastes, e.g. industrial waste, treatment concepts will be presented and developed by students themselves</p> <p>Waste composition and production on international level, waste eulogistic, collection and treatment in emerging and developing countries.</p> <p>Single national projects and studies will be prepared and presented by students</p>
<b>Literature</b>	Basel convention

Course L3260: International waste concepts	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M2032: Advanced Vadose Zone Hydrology	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
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
<b>Module Responsible</b>	Prof. Nima Shokri
<b>Admission Requirements</b>	None
<b>Recommended Previous Knowledge</b>	Basic knowledge in water and soil Comfortable with math and physics, critical thinking, creative problem solving Analytic skills
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
<i>Knowledge</i>	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
<i>Skills</i>	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.
<b>Personal Competence</b>	
<i>Social Competence</i>	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.
<i>Autonomy</i>	The students will be involved in many problem solving exercises. This will contribute toward their willingness to work independently and responsibly.
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
<b>Credit points</b>	6
<b>Course achievement</b>	None
<b>Examination</b>	Written elaboration
<b>Examination duration and scale</b>	Report and Presentation
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory 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

Course L2735: Modeling Processes in Vadose Zone	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Mohammad Aziz Zarif
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	Numerical tools will be introduced and used to quantify flow and transport processes in soil
<b>Literature</b>	NA

Course L2732: Vadose Zone Hydrology	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Nima Shokri
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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
<b>Literature</b>	<ul style="list-style-type: none"> <li>- Environmental Soil Physics, by Daniel Hillel</li> <li>- Soil Physics, Sixth Edition, by William A. Jury and Robert Horton</li> <li>- Physical Hydrology, Second Edition, by S. Lawrence Dingman</li> <li>- Introduction to Physical Hydrology, by Martin R. Hendriks</li> </ul>

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

Module M0801: Water Resources and -Supply				
Courses				
Title	Typ	Hrs/wk	CP	
Chemistry of Drinking Water Treatment (L0311)	Lecture	2	1	
Chemistry of Drinking Water Treatment (L0312)	Recitation Section (large)	1	2	
Water Resource Management (L0402)	Lecture	2	2	
Water Resource Management (L0403)	Recitation Section (small)	1	1	
<b>Module Responsible</b>	Prof. Mathias Ernst			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Knowledge of water management and the key processes involved in water treatment.			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.			
<i>Skills</i>	Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.			
<i>Autonomy</i>	Students will be in a position to work on a subject independently and present on this subject.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	60 min (chemistry) + presentation			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: 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: Elective Compulsory			

Course L0311: Chemistry of Drinking Water Treatment	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The topic of this course is water chemistry with respect to drinking water treatment and water distribution</p> <p>Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards).</p> <p>Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework.</p> <p>Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course "Water resources management" in the beginning of the semester.</p>
<b>Literature</b>	<p><b>MHW (rev. by Crittenden, J. et al.):</b> Water treatment principles and design. John Wiley &amp; Sons, Hoboken, 2005.</p> <p><b>Stumm, W., Morgan, J.J.:</b> Aquatic chemistry. John Wiley &amp; Sons, New York, 1996.</p> <p><b>DVGW (Hrsg.):</b> Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.</p> <p><b>Jensen, J. N.:</b> A Problem Solving Approach to Aquatic Chemistry. John Wiley &amp; Sons, Inc., New York, 2003.</p>

Course L0312: Chemistry of Drinking Water Treatment	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L0402: Water Resource Management	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Mathias Ernst
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The lecture provides comprehensive knowledge on interaction of water resource management and drinking water supply. Content overview:</p> <ul style="list-style-type: none"> <li>• Current situation of global water resources</li> <li>- User and Stakeholder conflicts</li> <li>- Wasserressourcenmanagement in urbane Gebieten</li> <li>- Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen.</li> <li>- Ökobilanzierung, Benchmarking in der Wasserversorgung</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Aktuelle UN World Water Development Reports</li> <li>• Branchenbild der deutschen Wasserwirtschaft, VKU (2011)</li> <li>• Aktuelle Artikel wissenschaftlicher Zeitschriften</li> <li>• Ppt der Vorlesung</li> </ul>

Module Manual M.Sc. "Water and Environmental Engineering"

<b>Course L0403: Water Resource Management</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Mathias Ernst
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

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	
<b>Module Responsible</b>	Prof. Mathias Ernst			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge of water chemistry. Knowledge of the core processes involved in water, gas and steam treatment			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> 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.</p> <p><i>Autonomy</i> 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.</p>			
<b>Workload in Hours</b>				
<b>Credit points</b>				
<b>Course achievement</b>				
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	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 General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Mathias Ernst
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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 electrodialysis, 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.</p> <p>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.</p> <p>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.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage), Springer-Verlag, Berlin 2004.</li> <li>• Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands</li> <li>• Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley &amp; Sons, Ltd., 2004</li> </ul>

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

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

Module M0822: Process Modeling in Water Technology			
Courses			
Title	Typ	Hrs/wk	CP
Process Modelling of Wastewater Treatment (L0522)	Project-/problem-based Learning	2	3
Process Modeling in Drinking Water Treatment (L0314)	Project-/problem-based Learning	2	3
<b>Module Responsible</b>	Dr. Klaus Johannsen		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Knowledge of the most important processes in drinking water and waste water treatment.		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p>		
<b>Personal Competence</b>	<p><i>Social Competence</i> 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.</p> <p><i>Autonomy</i> Students are able to define a problem, gain the required knowledge and set up a model.</p>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: 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		

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

<b>Course L0314: Process Modeling in Drinking Water Treatment</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>In the beginning of the course the use of OpenModelica is explained 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.</p>
<b>Literature</b>	<p><b>OpenModelica:</b> <a href="https://openmodelica.org/index.php/download/download-windows">https://openmodelica.org/index.php/download/download-windows</a></p> <p><b>OpenModelica - Modelica Tutorial:</b> <a href="https://openmodelica.org/index.php/useresresources/userdocumentation">https://openmodelica.org/index.php/useresresources/userdocumentation</a></p> <p><b>OpenModelica - Users Guide:</b> <a href="https://openmodelica.org/index.php/useresresources/userdocumentation">https://openmodelica.org/index.php/useresresources/userdocumentation</a></p> <p><b>Peter Fritzson:</b> Principles of Object-Oriented Modeling and Simulation with Modelica 2.1, Wiley-IEEE Press, ISBN 0-471-471631.</p> <p><b>MHW (rev. by Crittenden, J. et al.):</b> Water treatment principles and design. John Wiley &amp; Sons, Hoboken, 2005.</p> <p><b>Stumm, W., Morgan, J.J.:</b> Aquatic chemistry. John Wiley &amp; Sons, New York, 1996.</p> <p><b>DVGW (Hrsg.):</b> Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.</p>

Module M1505: Adaptation to Climate Change in Hydraulic Engineering (AKWAS)			
Courses			
Title	Typ	Hrs/wk	CP
Adaptation to climate change in hydraulic engineering (L2291)	Project-/problem-based Learning	4	6
<b>Module Responsible</b>	Prof. Peter Fröhle		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Hydrology, Hydraulic Engineering</li> <li>• Hydromechanic, Hydraulics</li> <li>• Fundamentals of Coastal Engineering, Coastal- and Flood Protection</li> <li>• Hydrological Systems</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>• Climate protection and climate adaptation</li> <li>• Insights into climate change and its regional characteristics - fundamentals, climate modelling / climate models</li> <li>• Impacts of climate change on the components of the regional hydrological cycle</li> <li>• Fundamentals of analysis of climate data</li> <li>• Consequences of the impact of the climate change</li> <li>• Measures for climate adaptation</li> <li>• Assessment, prioritization and communication of adaptation measures</li> <li>• Fundamentals of the analysis of hydrometeorological and hydrological data</li> </ul>		
<b>Professional Competence</b> <i>Skills</i>	<ul style="list-style-type: none"> <li>• Critical thinking: analysis of processes and relations, assessment of needs for action</li> <li>• Creative thinking: development of adaptation strategies and adaptation measures</li> <li>• Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods</li> <li>• Consideration of complex tasks</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Working in heterogenous groups</li> <li>• Working with different scientific / non-scientific disciplines</li> <li>• Self reflection</li> </ul>		
<b>Personal Competence</b> <i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Application oriented use of knowledge and skills</li> <li>• Autonomous work on complex tasks</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	Preparation of a written report and a presentation of a complex task.		
<b>Assignment for the Following Curricula</b>	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 Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory		

<b>Course L2291: Adaptation to climate change in hydraulic engineering</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Peter Fröhle
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Climate protection and climate adaptation</li> <li>• Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models</li> <li>• Impacts of climate change on the components of the regional hydrological cycle(climate science view)</li> <li>• Fundamentals of the analysis of climate data</li> <li>• Consequences of the impacts of climate change (ingenieering science view)</li> <li>• Measures for climate change adaptation</li> <li>• Assessment, prioritization and communication of measures</li> <li>• Fundamentals of analysis of hydrometeorological and hydrological data</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Wird bereitgestellt über die HOOU - eLearning Plattform</li> <li>• abhängig von den jeweils schwerpunktmäßig behandelten Fragestellungen wird das Schrifttum (aktuelle Paper) in der Veranstaltung bzw. über StudIP zur Verfügung gestellt.</li> </ul>

**Module M1123: Selected Topics in Environmental Engineering**

<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Environmental Aquatic Chemistry (L1444)	Lecture	2	3
Solid Matter Process Technology for Biomass (L0052)	Lecture	2	3
Sustainable landfill design and operation (L3270)	Integrated Lecture	3	3
Sludge Treatment (L0520)	Lecture	2	3
Special topics of the Environmental engineering 1CP (L3289)		1	1
Special topics of the Environmental engineering 2CP (L3290)		2	2
Special topics of the Environmental engineering 3CP (L3291)		3	3
Thermal Biomass Utilization (L1767)	Lecture	2	2
Thermal Biomass Utilization (L2386)	Practical Course	1	1
<b>Module Responsible</b>	Prof. Mathias Ernst		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i>			
<b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>			
<b>Workload in Hours</b>	Depends on choice of courses		
<b>Credit points</b>	6		
<b>Assignment for the Following Curricula</b>	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**

<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Concentration and activity</li> <li>• Gas-water partitioning</li> <li>• Acid/base equilibria</li> <li>• Alkalinity and acidity</li> <li>• Precipitation/dissolution equilibria</li> <li>• Redox equilibria</li> <li>• Complex formation</li> <li>• Sorption</li> </ul>
<b>Literature</b>	Worch, E.: Hydrochemistry. Basic Concepts and Exercises. De Gruyter, Berlin, 2015

Course L0052: Solid Matter Process Technology for Biomass	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Werner Sitzmann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture.
<b>Literature</b>	Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamasse, Springer Verlag, 2001, ISBN 3-540-64853-4  Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe, Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de  Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175

Course L3270: Sustainable landfill design and operation	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Dr. Marco Ritzkowski
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	The course introduces the development of modern waste resource management and demonstrates the importance of landfills in the context of recycling processes. Based on international (EU) and national legislation, the current landfill situation is presented and the future significance of landfills will be discussed. A central element of the course deals with the main transformation processes in the landfilled waste, the emission of gases and leachate, the long-term behaviour of landfills as well as aftercare and after-utilisation measures. Further focal points of the course are measures for the sustainable reduction of environmentally and climate-damaging emissions and aspects of landfill technology in an international context.
<b>Literature</b>	1) <b>Waste Management.</b> Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305  2) <b>Solid Waste Technology and Management.</b> Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332  3) <b>Solid Waste Landfilling - Concepts, Processes, Technologies.</b> Cossu, R. and Stegmann, R. (Eds.), ISBN: 978-0-12-818336-6  PDF (Volltext) über TUB

Course L0520: Sludge Treatment	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Dr. Joachim Behrendt
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	<b>Tchobanoglous, George</b> (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 <b>Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes</b> Sludge Treatment and Disposal ISBN 9781843391661 IWA Publishing, 2007

Course L3289: Special topics of the Environmental engineering 1CP	
<b>Typ</b>	
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Fachtheoretisch-fachpraktische Arbeit
<b>Examination duration and scale</b>	wird zu Beginn der Veranstaltung festgelegt
<b>Lecturer</b>	Dozenten des SD B
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	The course occurs only if required. The content is defined at short notice.
<b>Literature</b>	Die Literatur wird kurzfristig festgelegt.

Course L3290: Special topics of the Environmental engineering 2CP	
<b>Typ</b>	
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Fachtheoretisch-fachpraktische Arbeit
<b>Examination duration and scale</b>	wird zu Beginn der Veranstaltung festgelegt
<b>Lecturer</b>	Dozenten des SD B
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	The course occurs only if required. The content is defined at short notice.
<b>Literature</b>	Die Literatur wird kurzfristig festgelegt.

Course L3291: Special topics of the Environmental engineering 3CP	
<b>Typ</b>	
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Fachtheoretisch-fachpraktische Arbeit
<b>Examination duration and scale</b>	wird zu Beginn der Veranstaltung festgelegt
<b>Lecturer</b>	Dozenten des SD B
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	The course occurs only if required. The content is defined at short notice.
<b>Literature</b>	Die Literatur wird kurzfristig festgelegt.

Course L1767: Thermal Biomass Utilization	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Martin Kaltschmitt
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>The course is structured as follows:</p> <ul style="list-style-type: none"> <li>• Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course</li> <li>• Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste</li> <li>• Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying</li> <li>• Thermo-chemical conversion of solid biofuels <ul style="list-style-type: none"> <li>◦ Basics of thermo-chemical conversion</li> <li>◦ 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</li> <li>◦ Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels</li> <li>◦ 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</li> </ul> </li> <li>• 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)</li> <li>• Bio-chemical conversion of biomass <ul style="list-style-type: none"> <li>◦ Basics of bio-chemical conversion</li> <li>◦ 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</li> <li>◦ Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage</li> </ul> </li> </ul>
<b>Literature</b>	<b>Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage</b>

<b>Course L2386: Thermal Biomass Utilization</b>	
<b>Typ</b>	Practical Course
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Schriftliche Ausarbeitung
<b>Examination duration and scale</b>	Protokolle
<b>Lecturer</b>	Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>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.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- Kaltschmitt, Martin; Hartmann, Hans; Hofbauer, Hermann: Energie aus Biomasse: Grundlagen, Techniken und Verfahren. 3. Auflage. Berlin Heidelberg: Springer Science &amp; Business Media, 2016. -ISBN 978-3-662-47437-2</li> <li>- Versuchsskript</li> </ul>

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					
<b>Module Responsible</b>	Prof. Nima Shokri							
<b>Admission Requirements</b>	None							
<b>Recommended Previous Knowledge</b>	Basic knowledge on water, soil and environmental research.							
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results							
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.</p> <p><i>Autonomy</i> 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.</p>							
<b>Workload in Hours</b>					Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>					6			
<b>Course achievement</b>	None							
<b>Examination</b>	Subject theoretical and practical work							
<b>Examination duration and scale</b>	Report and Presentation							
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Seminar
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Salome Shokri-Kuehni
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Introduction - course objectives, expectations and format</p> <p>Analyzing the Audience, purpose and occasion</p> <p>Constructing and delivering effective technical presentations</p> <p>How to write an abstract</p> <p>How to write a scientific paper</p> <p>Developing competitive and persuasive research proposals</p> <p>Databases and resources available for water and environmental research</p> <p>Individual proposal on water and environmental research</p> <p>Individual project on water and environmental research</p> <p>Presentation on water and environmental research</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9</li> <li>• Supplemental materials and web links which will be available to registered students.</li> </ul>

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

<b>Course L2751: Scientific Communication and Methods</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Nima Shokri
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Introduction - course objectives, expectations and format</p> <p>Analyzing the Audience, purpose and occasion</p> <p>Constructing and delivering effective technical presentations</p> <p>How to write an abstract</p> <p>How to create a scientific poster</p> <p>How to write a scientific paper</p> <p>Developing competitive and persuasive research proposals</p> <p>Individual project (report and presentation) related to soil, water and environmental research</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9</li> <li>• Supplemental materials and web links which will be available to registered students.</li> </ul>

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	
<b>Module Responsible</b>	Prof. Peter Fröhle			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Hydraulic Engineering</li> <li>• Hydromechanics, Hydraulics</li> <li>• Fundamentals of Coastal Engineering, Coastal- and Flood Protection</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>• Climate and Climate Change</li> <li>• General Impacts of Climate Change on Wind Regime and Water Cycle</li> <li>• Consequences of Climate Change for Coastal Processes</li> <li>• Coastal Protection in Taiwan and Germany</li> <li>• Fundamentals of Climate Adaptation</li> <li>• Nature-based Solutions (NBS) for Coastal Protection</li> </ul>			
<i>Skills</i>	<ul style="list-style-type: none"> <li>• Critical thinking: analysis of processes and relations, assessment of needs for action</li> <li>• Creative thinking: development of adaptation strategies and adaptation measures</li> <li>• Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods</li> <li>• Consideration of complex tasks</li> </ul>			
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Working in heterogenous groups</li> <li>• Working in international groups</li> <li>• Working with different scientific / non-scientific disciplines</li> <li>• Self reflection</li> </ul>			
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Application oriented use of knowledge and skills</li> <li>• Autonomous work on complex tasks</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written elaboration			
<b>Examination duration and scale</b>	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.			
<b>Assignment for the Following Curricula</b>	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			

<b>Course L2926: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Peter Fröhle, Prof. Frank Thorenz
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Climate and Climate Change</li> <li>• General Impacts of Climate Change on Wind Regime and Water Cycle</li> <li>• Consequences of Climate Change for Coastal Processes</li> <li>• Coastal Protection in Taiwan and Germany</li> <li>• Fundamentals of Climate Adaptation</li> <li>• Nature-Based Solutions (NBS) for Coastal Protection</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Materials provided on eLearning Platform (HOOU Platform)</li> <li>• 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.</li> </ul>

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
<b>Module Responsible</b>	Prof. Peter Fröhle		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Coastal Engineering I		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p>		
<b>Personal Competence</b>	<p><i>Social Competence</i> 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. Additionally, they will be able to work in team with engineers of other disciplines.</p> <p><i>Autonomy</i> The students will be able to independently extend their knowledge and apply it to new problems.</p>		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	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.		
<b>Assignment for the Following Curricula</b>	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		

<b>Course L0808: Coastal- and Flood Protection</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Peter Fröhle, Prof. Frank Thorenz
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Protection of sandy coasts</p> <ul style="list-style-type: none"> <li>• Sediment transport</li> <li>• Morphology</li> <li>• Technical solution for the protection of sandy coasts <ul style="list-style-type: none"> <li>◦ Construction in direction of the coast</li> <li>◦ Constructions perpendicular to the coast</li> <li>◦ Other Concept</li> </ul> </li> <li>• Calculation approaches and numerical models</li> </ul> <p>Flood Protection</p> <ul style="list-style-type: none"> <li>• Classification of constructions / measures</li> <li>• Dikes</li> <li>• Dunes</li> <li>• Foreland - constructions</li> <li>• Flood-Protection Walls</li> <li>• Drainage of the hinterland</li> </ul>
<b>Literature</b>	<p>Vorlesungsumdruck</p> <p>Coastal Engineering Manual CEM</p>

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

<b>Course L1411: Maintenance and Defence of Flood Protection Structures</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Olaf Müller
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Dike protection</li> <li>• Maintenance of flood protection measures</li> </ul>
<b>Literature</b>	Vorlesungsumdruck

Module M2003: Biological Waste Treatment				
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	
<b>Module Responsible</b>	Prof. Kerstin Kuchta			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	chemical and biological basics			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	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.			
<b>Personal Competence</b>				
<i>Social Competence</i>	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.			
<i>Autonomy</i>	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.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	None	Subject	theoretical and practical work
<b>Examination</b>	Presentation			
<b>Examination duration and scale</b>	Elaboration and Presentation (15-25 minutes in groups)			
<b>Assignment for the Following Curricula</b>	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 Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical and Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical and Bioprocess Engineering: Elective Compulsory Environmental Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory			

<b>Course L0328: Waste and Environmental Chemistry</b>	
<b>Typ</b>	Practical Course
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation.</p> <p>Experiments are e.g.</p> <p>Screening and particle size determination</p> <p>Fos/Tac</p> <p>AAS</p> <p>Chalorific value</p>
<b>Literature</b>	Scripte

<b>Course L0318: Biological Waste Treatment</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Kerstin Kuchta
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. biological basics</li> <li>3. determination process specific material characterization</li> <li>4. aerobic degradation ( Composting, stabilization)</li> <li>5. anaerobic degradation (Biogas production, fermentation)</li> <li>6. Technical layout and process design</li> <li>7. Flue gas treatment</li> <li>8. Plant design practical phase</li> </ol>
<b>Literature</b>	

Module M2013: Study Work Specialisation Environment			
Courses			
Title	Typ	Hrs/wk	CP
<b>Module Responsible</b>	Dozenten des SD B		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	<p>The students are able to demonstrate their detailed knowledge in the field of Water and Environmental Engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society.</p> <p>The students can develop solving strategies and approaches for fundamental and practical problems in the field of Water and Environmental Engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society.</p> <p>Scientific work techniques that are used can be described and critically reviewed.</p>		
<i>Skills</i>	The students are able to independently select methods or planning approaches for the project work and to justify their choice. They can explain how these methods or approaches relate to solutions in the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.		
<b>Personal Competence</b>			
<i>Social Competence</i>	The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.		
<i>Autonomy</i>	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.		
<b>Workload in Hours</b>	Independent Study Time 360, Study Time in Lecture 0		
<b>Credit points</b>	12		
<b>Course achievement</b>	None		
<b>Examination</b>	Study work		
<b>Examination duration and scale</b>			
<b>Assignment for the Following Curricula</b>	Water and Environmental Engineering: Specialisation Environment: Compulsory		

Module M2033: Subsurface Processes						
<b>Courses</b>						
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>			
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			
<b>Module Responsible</b>	Dr. Milad Aminzadeh					
<b>Admission Requirements</b>	None					
<b>Recommended Previous Knowledge</b>	Basic Mathematics, Hydrology					
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results					
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Teamwork &amp; problem solving</p> <p><i>Autonomy</i> 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.</p>					
<b>Workload in Hours</b>				Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>				6		
<b>Course achievement</b>				None		
<b>Examination</b>	Subject theoretical and practical work					
<b>Examination duration and scale</b>	Report					
<b>Assignment for the Following Curricula</b>	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 Chemical and Bioprocess Engineering: Technical Complementary Course: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: 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					
Course L2731: Modeling of Subsurface Processes						
<b>Typ</b>	Recitation Section (small)					
<b>Hrs/wk</b>	3					
<b>CP</b>	3					
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42					
<b>Lecturer</b>	Mohammad Aziz Zarif					
<b>Language</b>	EN					
<b>Cycle</b>	WiSe					
<b>Content</b>	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					
<b>Literature</b>						

Course L2728: Subsurface Solute Transport	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Milad Aminzadeh
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	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)
<b>Literature</b>	- Environmental Soil Physics, by Daniel Hillel - Soil Physics, Sixth Edition, by William A. Jury and Robert Horton

Course L2729: Subsurface Solute Transport	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Milad Aminzadeh
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M2076: Introduction to Climate Informed Engineering	
<b>Courses</b>	
<b>Title</b>	<b>Typ</b> <b>Hrs/wk</b> <b>CP</b>
Methods in Climate Informed Engineering (L3347)	Lecture 3 3
Topics in Climate Informed Engineering (L3348)	Lecture 3 3
<b>Module Responsible</b>	Prof. Nima Shokri
<b>Admission Requirements</b>	None
<b>Recommended Previous Knowledge</b>	Students are expected to have a foundational understanding of environmental science, basic engineering principles, and an interest in sustainability. Recommended knowledge includes climate science, data analysis, and familiarity with engineering design processes. Analytical and critical thinking and creative problem-solving skills are also beneficial
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
<i>Knowledge</i>	This module explores next-generation climate models and high-resolution data, emphasizing their impact on environmental and engineering products and processes. It covers how various engineering disciplines can benefit from climate information. Research-based learning activities, expert talks, and presentations will expose students to state-of-the-art modeling, measurement, and analysis in climate-informed engineering.
<i>Skills</i>	Climate data analysis, engineering adaptation strategies, problem-solving, research-based learning, and interdisciplinary collaboration.
<b>Personal Competence</b>	
<i>Social Competence</i>	Collaboration, interdisciplinary teamwork, communication skills, problem-solving, ethical responsibility, and decision-making in climate-resilient engineering.
<i>Autonomy</i>	Time management, self-directed learning, critical thinking, accountability, initiative, and the ability to conduct independent research and make informed decisions in climate-informed engineering.
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
<b>Credit points</b>	6
<b>Course achievement</b>	None
<b>Examination</b>	Subject theoretical and practical work
<b>Examination duration and scale</b>	Report and Presentation
<b>Assignment for the Following Curricula</b>	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 Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Data Science: Specialisation III. Applications: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Process Engineering: Specialisation Process Engineering: 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 L3347: Methods in Climate Informed Engineering	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Nima Shokri, Prof. Cathy Hohenegger, Prof. Irina Smirnova
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	Students will learn techniques for incorporating climate data and environmental factors into engineering design. It covers climate modelling and the use of sensors and devices to measure climate-related parameters and engineering processes. Students will have the opportunity to conduct their own measurements, analyze the collected data, and write a report on their findings. This hands-on experience will be assessed and contribute to their final grade.
<b>Literature</b>	

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<b>Course L3348: Topics in Climate Informed Engineering</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Irina Smirnova, Prof. Cathy Hohenegger, Prof. Nima Shokri
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	Exploring specific applications of climate data in various engineering disciplines. Invited speakers will present their research and discuss the relevance of climate-informed engineering to their work. Additionally, there will be a segment on effective communication, covering how to give impactful presentations and write research papers. Students will also give presentations on their own class projects related to climate-informed engineering, applying the concepts they've learned. This hands-on experience will be assessed and contribute to their final grade.
<b>Literature</b>	

Module M2155: Uncertainty Modelling for Engineers				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Uncertainty Modelling for Engineers (L3458)		Integrated Lecture	6	6
<b>Module Responsible</b>	Prof. Simon Michael Papalexiou			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ol style="list-style-type: none"> <li>1. General familiarity with engineering concepts.</li> <li>2. Elementary probability and statistics, and mathematical skills.</li> <li>3. Basic computer skills for handling data.</li> <li>4. Interest in solving engineering problems using statistical and probabilistic methods.</li> </ol>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students will develop a strong foundation in uncertainty, probability, and risk analysis in engineering applications. The course introduces probability as a measure of uncertainty, covering frequency-based methods. Students will explore Bayes' Theorem, probability distributions, extreme value theory, joint probability distributions, and stochastic optimization to model and quantify uncertainty in engineering problems. The course also covers linear and nonlinear regression methods, essential for data-driven decision-making and predictive modeling. Additionally, students will gain insight into risk assessment as a function of probability and disutility and learn how to apply Bayesian Decision Theory to optimize engineering solutions under uncertainty.			
<i>Skills</i>	By the end of the course, students will be able to apply probabilistic models to quantify uncertainty and assess risks in engineering problems. They will gain expertise in fitting probability distributions, performing extreme value analysis, and applying Bayesian inference to real-world engineering challenges. Students will also develop skills in linear and nonlinear regression modeling, enabling them to analyze complex engineering datasets and improve risk predictions. Through hands-on computational exercises, they will learn to implement stochastic methods and optimization techniques to support reliability-based design and engineering decision-making.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students will develop the ability to work collaboratively on engineering risk assessments, communicating technical results effectively with peers, engineers, and decision-makers. They will engage in discussions on risk perception, safety factors, and uncertainty quantification, ensuring that engineering analyses are both rigorous and applicable to real-world infrastructure challenges.			
<i>Autonomy</i>	Students will learn to independently analyze and model engineering uncertainties, selecting and applying appropriate probability distributions, regression methods, and stochastic techniques for various applications. They will also gain the ability to evaluate risks associated with natural and human-made hazards, ensuring they can make informed engineering decisions in design, safety assessment, and disaster mitigation.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	20 %	Presentation	10-minütige Präsentation von Arbeitsergebnissen
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	150 min			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory 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 Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory			

<b>Course L3458: Uncertainty Modelling for Engineers</b>	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	6
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
<b>Lecturer</b>	Prof. Simon Michael Papalexiou
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Engineering decisions are rarely made with complete certainty—uncertainty affects material properties, environmental conditions, structural performance, and risk assessments. This course provides students with theoretical foundations and practical tools to quantify uncertainty, assess risks, and enhance decision-making in civil, structural, geotechnical, and environmental engineering applications. Students will begin with fundamental probability concepts, learning how Bayes' Theorem, probability distributions, and extreme value theory help evaluate engineering uncertainties. They will explore linear and nonlinear regression methods for analyzing complex datasets, as well as joint probability distributions and stochastic optimization to improve predictive modeling and reliability assessments. The course also introduces Bayesian Decision Theory, offering a structured approach to decision-making under uncertainty. With a focus on real-world engineering problems, students will apply probabilistic models, extreme value analysis, and stochastic techniques to assess risks in infrastructure design, system reliability, and disaster resilience. Hands-on computational exercises will reinforce key concepts, preparing students to work with data-driven models and uncertainty quantification techniques used in engineering practice. This course is ideal for students interested in engineering risk assessment, reliability analysis, and data-driven modeling. By the end of the course, students will have developed critical analytical and problem-solving skills, equipping them for careers in structural safety, geotechnical engineering, environmental risk management, and beyond.</p>
<b>Literature</b>	

## Specialization Water

### Module M0801: Water Resources and -Supply

#### Courses

Title	Typ	Hrs/wk	CP
Chemistry of Drinking Water Treatment (L0311)	Lecture	2	1
Chemistry of Drinking Water Treatment (L0312)	Recitation Section (large)	1	2
Water Resource Management (L0402)	Lecture	2	2
Water Resource Management (L0403)	Recitation Section (small)	1	1

<b>Module Responsible</b>	Prof. Mathias Ernst
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<b>Admission Requirements</b>	None
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<b>Recommended Previous Knowledge</b>	Knowledge of water management and the key processes involved in water treatment.
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<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
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<b>Professional Competence</b>	
<i>Knowledge</i>	Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application.
<i>Skills</i>	Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes.
<b>Personal Competence</b>	
<i>Social Competence</i>	Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others.
<i>Autonomy</i>	Students will be in a position to work on a subject independently and present on this subject.

<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
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<b>Credit points</b>	6
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<b>Course achievement</b>	None
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<b>Examination</b>	Written exam
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<b>Examination duration and scale</b>	60 min (chemistry) + presentation
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<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: 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: Elective Compulsory
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Course L0311: Chemistry of Drinking Water Treatment	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The topic of this course is water chemistry with respect to drinking water treatment and water distribution</p> <p>Major topics are solubility of gases, carbonic acid system and calcium carbonate, blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards).</p> <p>Special emphasis is put on calculations using realistic analysis data (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework.</p> <p>Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course "Water resources management" in the beginning of the semester.</p>
<b>Literature</b>	<p><b>MHW (rev. by Crittenden, J. et al.):</b> Water treatment principles and design. John Wiley &amp; Sons, Hoboken, 2005.</p> <p><b>Stumm, W., Morgan, J.J.:</b> Aquatic chemistry. John Wiley &amp; Sons, New York, 1996.</p> <p><b>DVGW (Hrsg.):</b> Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.</p> <p><b>Jensen, J. N.:</b> A Problem Solving Approach to Aquatic Chemistry. John Wiley &amp; Sons, Inc., New York, 2003.</p>

Course L0312: Chemistry of Drinking Water Treatment	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L0402: Water Resource Management	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Mathias Ernst
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>The lecture provides comprehensive knowledge on interaction of water resource management and drinking water supply. Content overview:</p> <ul style="list-style-type: none"> <li>• Current situation of global water resources</li> <li>- User and Stakeholder conflicts</li> <li>- Wasserressourcenmanagement in urbane Gebieten</li> <li>- Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen.</li> <li>- Ökobilanzierung, Benchmarking in der Wasserversorgung</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Aktuelle UN World Water Development Reports</li> <li>• Branchenbild der deutschen Wasserwirtschaft, VKU (2011)</li> <li>• Aktuelle Artikel wissenschaftlicher Zeitschriften</li> <li>• Ppt der Vorlesung</li> </ul>

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<b>Course L0403: Water Resource Management</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Mathias Ernst
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M2033: Subsurface Processes			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Prof. Nima Shokri		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic Mathematics, Hydrology		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p>		
<b>Personal Competence</b>	<p><i>Social Competence</i> Teamwork &amp; problem solving</p> <p><i>Autonomy</i> 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.</p>		
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Subject theoretical and practical work		
<b>Examination duration and scale</b>	Report		
<b>Assignment for the Following Curricula</b>	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 Chemical and Bioprocess Engineering: Technical Complementary Course: 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		

Course L2731: Modeling of Subsurface Processes	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Mohammad Aziz Zarif
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	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
<b>Literature</b>	

Course L2728: Subsurface Solute Transport	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Milad Aminzadeh
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	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)
<b>Literature</b>	- Environmental Soil Physics, by Daniel Hillel - Soil Physics, Sixth Edition, by William A. Jury and Robert Horton

Course L2729: Subsurface Solute Transport	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Milad Aminzadeh
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0513: System Aspects of Renewable Energies				
<b>Courses</b>				
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>	
Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021)	Lecture	2	2	
Energy Trading (L0019)	Lecture	1	1	
Energy Trading (L0020)	Recitation Section (small)	1	1	
Deep Geothermal Energy (L0025)	Lecture	2	2	
<b>Module Responsible</b>	Prof. Martin Kaltschmitt			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Module: Technical Thermodynamics I Module: Technical Thermodynamics II			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students are able to describe the processes in energy trading and the design of energy markets and can critically evaluate them in relation to current subject specific problems. Furthermore, they are able to explain the basics of thermodynamics of electrochemical energy conversion in fuel cells and can establish and explain the relationship to different types of fuel cells and their respective structure. Students can compare this technology with other energy storage options. In addition, students can give an overview of the procedure and the energetic involvement of deep geothermal energy.</p> <p><i>Skills</i> Students can apply the learned knowledge of storage systems for excessive energy to explain for various energy systems different approaches to ensure a secure energy supply. In particular, they can plan and calculate domestic, commercial and industrial heating equipment using energy storage systems in an energy-efficient way and can assess them in relation to complex power systems. In this context, students can assess the potential and limits of geothermal power plants and explain their operating mode.</p> <p>Furthermore, the students are able to explain the procedures and strategies for marketing of energy and apply it in the context of other modules on renewable energy projects. In this context they can unassistedly carry out analysis and evaluations of energie markets and energy trades.</p>			
<b>Personal Competence</b>				
<i>Social Competence</i>				
<i>Autonomy</i>	Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module.			
<i>Autonomy</i>	Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	3 hours written exam			
<b>Assignment for the Following Curricula</b>	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: 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			

Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Michael Fröba
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction to electrochemical energy conversion</li> <li>2. Function and structure of electrolyte</li> <li>3. Low-temperature fuel cell               <ul style="list-style-type: none"> <li>◦ Types</li> <li>◦ Thermodynamics of the PEM fuel cell</li> <li>◦ Cooling and humidification strategy</li> </ul> </li> <li>4. High-temperature fuel cell               <ul style="list-style-type: none"> <li>◦ The MCFC</li> <li>◦ The SOFC</li> <li>◦ Integration Strategies and partial reforming</li> </ul> </li> <li>5. Fuels               <ul style="list-style-type: none"> <li>◦ Supply of fuel</li> <li>◦ Reforming of natural gas and biogas</li> <li>◦ Reforming of liquid hydrocarbons</li> </ul> </li> <li>6. Energetic Integration and control of fuel cell systems</li> </ol>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003</li> </ul>

Course L0019: Energy Trading	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Robert Gersdorf
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Basic concepts and tradable products in energy markets</li> <li>• Primary energy markets</li> <li>• Electricity Markets</li> <li>• European Emissions Trading Scheme</li> <li>• Influence of renewable energy</li> <li>• Real options</li> <li>• Risk management</li> </ul> <p>Within the exercise the various tasks are actively discussed and applied to various cases of application.</p>
<b>Literature</b>	

Course L0020: Energy Trading	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Robert Gersdorf
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

<b>Course L0025: Deep Geothermal Energy</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Ben Norden
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction to the deep geothermal use</li> <li>2. Geological Basics I</li> <li>3. Geological Basics II</li> <li>4. Geology and thermal aspects</li> <li>5. Rock Physical Aspects</li> <li>6. Geochemical aspects</li> <li>7. Exploration of deep geothermal reservoirs</li> <li>8. Drilling technologies, piping and expansion</li> <li>9. Borehole Geophysics</li> <li>10. Underground system characterization and reservoir engineering</li> <li>11. Microbiology and Upper-day system components</li> <li>12. Adapted investment concepts, cost and environmental aspect</li> </ol>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Dipippo, R.: Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact. Butterworth Heinemann; 3rd revised edition. (29. Mai 2012)</li> <li>• <a href="http://www.geo-energy.org">www.geo-energy.org</a></li> <li>• Edenhofer et al. (eds): Renewable Energy Sources and Climate Change Mitigation; Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2012.</li> <li>• Kaltschmitt et al. (eds): Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer, 5. Aufl. 2013.</li> <li>• Kaltschmitt et al. (eds): Energie aus Erdwärme. Spektrum Akademischer Verlag; Auflage: 1999 (3. September 2001)</li> <li>• Huenges, E. (ed.): Geothermal Energy Systems: Exploration, Development, and Utilization. Wiley-VCH Verlag GmbH &amp; Co. KGaA; Auflage: 1. Auflage (19. April 2010)</li> </ul>

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	
<b>Module Responsible</b>	Prof. Peter Fröhle			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Fundamentals of Hydromechanics, Hydraulics, Hydrology and Hydraulic Engineering; Hydraulic Engineering I and Hydraulic Engineering II			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	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.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students are able to deploy their gained knowledge in applied problems of the practical nature-based hydraulic engineering. Additionally, they will be able to work in team with engineers of other disciplines.			
<i>Autonomy</i>	The students will be able to independently extend their knowledge and apply it to new problems.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	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.			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Edgar Nehlsen, Prof. Peter Fröhle
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Introduction to numerical flow modelling</p> <ul style="list-style-type: none"> <li>• Processes affecting the flow</li> <li>• Examples and applications of numerical models</li> <li>• Procedure of numerical modelling</li> <li>• Model concept</li> </ul> <p>Basic equations of hydrodynamics</p> <ul style="list-style-type: none"> <li>• Saint-Venant equations</li> <li>• Euler Equations</li> <li>• Navier-Stokes equations</li> <li>• Reynolds-averaged Navier-Stokes equations</li> <li>• Shallow water equations</li> </ul> <p>Solving schemes</p> <ul style="list-style-type: none"> <li>• Numerical discretization</li> <li>• Solution algorithms</li> <li>• Convergence</li> </ul>
<b>Literature</b>	<p>Vorlesungsskript</p> <p>Literaturempfehlungen</p> <p>Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau (1997): Hydraulische Berechnung von naturnahen Fließgewässern. Düsseldorf: BWK (BWK-Merkblatt).</p> <p>Chow, Ven-te (1959): Open-channel Hydraulics. New York usw.: McGraw-Hill (McGraw-Hill Civil Engineering Series).</p> <p>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).</p> <p>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).</p> <p>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).</p> <p>Hervouet, Jean-Michel (2007): Hydrodynamics of free surface flows. Modelling with the finite element method. Chichester: Wiley. Online verfügbar unter <a href="http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html">http://www.loc.gov/catdir/enhancements/fy0741/2007296953-b.html</a>.</p> <p>IAHR (2015): Professional Specifications for Physical and Numerical Studies in Environmental Hydraulics. In: Hydrolink (3/2015), S. 90-92.</p> <p>Olsen, Nils Reidar B. (2012): Numerical Modelling and Hydraulics. 3. Aufl. Department of Hydraulic and Environmental Engineering, The Norwegian University of Science and Technology.</p> <p>Szymkiewicz, Romuald (2010): Numerical modeling in open channel hydraulics. Dordrecht: Springer (Water science and technology library, 83).</p> <p>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).</p> <p>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).</p>

<b>Course L0961: Nature-Oriented Hydraulic Engineering / Integrated Flood Protection</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Natasa Manojlovic, Prof. Peter Fröhle
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Regime-Theory and application for the development of environmental guiding principles of rivers</li> <li>• Engineering - biological measures for the stabilization of rivers</li> <li>• Risk management in flood protection</li> <li>• Design techniques in technical flood protection</li> <li>• Methods for the assessment of flood caused damages</li> </ul>
<b>Literature</b>	Vorlesungsumdruck

Module M0874: Wastewater Systems			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Dr. Joachim Behrendt		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Knowledge of wastewater management and the key processes involved in wastewater treatment.		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	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.		
<i>Skills</i>	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.		
<b>Personal Competence</b>			
<i>Social Competence</i>	Social skills are not targeted in this module.		
<i>Autonomy</i>	Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.		
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Joachim Behrendt
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Charaterisation of Wastewater Metabolism of Microorganisms Kinetic of microbiotic 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
<b>Literature</b>	<b>Gujer, Willi</b> 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](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-Pföhren : 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](http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf) URL:  
[http://www.gbv.de/dms/weimar/abs/513989765\\_abs.pdf](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](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	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Joachim Behrendt
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

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

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

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	
<b>Module Responsible</b>	Prof. Ralf Otterpohl			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge of the global situation with rising poverty, soil degradation, migration to cities, lack of water resources and sanitation			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> Students are able to design ecological settlements for different geographic and socio-economic conditions for the main climates around the world.</p>			
<b>Personal Competence</b>	<p><i>Social Competence</i> The students are able to develop a specific topic in a team and to work out milestones according to a given plan.</p> <p><i>Autonomy</i> Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject.</p>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	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 semester in the StudIP course module handbook.			
<b>Assignment for the Following Curricula</b>	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			

<b>Course L1229: Ecological Town Design - Water, Energy, Soil and Food Nexus</b>	
<b>Typ</b>	Seminar
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Ralf Otterpohl
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Participants Workshop: Design of the most attractive productive Town</li> <li>• Keynote lecture and video</li> <li>• The limits of Urbanization / Green Cities</li> <li>• The tragedy of the Rural: Soil degradation, agro chemical toxification, migration to cities</li> <li>• Global Ecovillage Network: Upsides and Downsides around the World</li> <li>• Visit of an Ecovillage</li> <li>• Participants Workshop: Resources for thriving rural areas, Short presentations by participants, video competition</li> <li>• TUHH Rural Development Toolbox</li> <li>• Integrated New Town Development</li> <li>• Participants workshop: Design of New Towns: Northern, Arid and Tropical cases</li> <li>• Outreach: Participants campaign</li> <li>• City with the Rural: Resilience, quality of live and productive biodiversity</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• 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</li> <li>• <a href="http://youtu.be/9hmkgn0nBgk">http://youtu.be/9hmkgn0nBgk</a> (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> <li>• TEDx New Town Ralf Otterpohl: <a href="http://youtu.be/_M0J2u9BrbU">http://youtu.be/_M0J2u9BrbU</a></li> </ul>

<b>Course L0939: Water &amp; Wastewater Systems in a Global Context</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Ralf Otterpohl
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Keynote lecture and video</li> <li>• Water &amp; Soil: Water availability as a consequence of healthy soils</li> <li>• Water and it's utilization, Integrated Urban Water Management</li> <li>• Water &amp; Energy, lecture and panel discussion pro and con for a specific big dam project</li> <li>• Rainwater Harvesting on Catchment level, Holistic Planned Grazing, Multi-Use-Reforestation</li> <li>• Sanitation and Reuse of water, nutrients and soil conditioners, Conventional and Innovative Approaches</li> <li>• Why are there excreta in water? Public Health, Awareness Campaigns</li> <li>• Rehearsal session, Q&amp;A</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press</li> <li>• Liu, John D.: <a href="http://eempc.org/hope-in-a-changing_climate/">http://eempc.org/hope-in-a-changing_climate/</a> (Integrated regeneration of the Loess Plateau, China, and sites in Ethiopia and Rwanda)</li> <li>• <a href="http://youtu.be/9hmkgn0nBgk">http://youtu.be/9hmkgn0nBgk</a> (Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation)</li> </ul>

Module M1721: Water and Environment: Theory and Application				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Water and Environment (L2754)		Project-/problem-based Learning	3	3
Water and Environment (L2753)		Lecture	3	3
<b>Module Responsible</b>	Prof. Nima Shokri			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge in water and environmental research, Hydrology			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	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.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.			
<i>Autonomy</i>	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.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	Report and Presentation			
<b>Assignment for the Following Curricula</b>	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				
<b>Typ</b>	Project-/problem-based Learning			
<b>Hrs/wk</b>	3			
<b>CP</b>	3			
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42			
<b>Lecturer</b>	Dr. Salome Shokri-Kuehni			
<b>Language</b>	EN			
<b>Cycle</b>	SoSe			
<b>Content</b>	See interlocking course			
<b>Literature</b>	See interlocking course			
Course L2753: Water and Environment				
<b>Typ</b>	Lecture			
<b>Hrs/wk</b>	3			
<b>CP</b>	3			
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42			
<b>Lecturer</b>	Prof. Nima Shokri			
<b>Language</b>	EN			
<b>Cycle</b>	SoSe			
<b>Content</b>	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.			
<b>Literature</b>	NA			

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	
<b>Module Responsible</b>	Prof. Kay Smarsly			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	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.			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	The students will gain insights into operating state-of-the-art smart sensor systems, used for monitoring a wide range of physical processes relevant to engineering, such as environmental, structural, or comfort monitoring. The students will be capable of devising monitoring strategies of physical processes as part of group projects, tailored to their knowledge backgrounds, and to implement the strategies in smart wireless sensor nodes, using embedded computing and programming. Finally, the students will be able to document the findings of their projects in short reports.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students will be able to work in groups, share parts of the work for their projects, and develop communication skills, towards achieving the common project goals.			
<i>Autonomy</i>	The students will be able to gain a solid basis on approaching and solving problems in engineering, as well as on documenting results, through their involvement in their monitoring group projects.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written elaboration			
<b>Examination duration and scale</b>	10 pages of work with 15-minute oral presentation			
<b>Assignment for the Following Curricula</b>	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 Computer Science: Specialisation II: Intelligence 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 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	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kay Smarsly
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Course L2763: Smart Monitoring	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Kay Smarsly
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	The course contents couples different fields, such as signal processing, sensing technologies, data analytics, environmental engineering, civil engineering, artificial intelligence, database systems, and many more. The basics will be taught in this course. However, specific literature that covers all these topics does not exist. Instead, literature will be referenced in the lectures, all of which are papers that are freely available online.

Module M0858: Coastal Hydraulic Engineering I			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Basics of Coastal Engineering (L0807)	Lecture	3	4
Basics of Coastal Engineering (L1413)	Project-/problem-based Learning	1	2
<b>Module Responsible</b>	Prof. Peter Fröhle		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basics of hydraulic engineering, hydrology and hydromechanics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> The students are capable to apply basic design approaches to selected and pre-defined design tasks in coastal engineering.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students are able to deploy their gained knowledge in applied problems such as the design of coastal protection structures. Additionally, they will be able to work in team with engineers of other disciplines, for instance designing of coastal breakwaters.</p> <p><i>Autonomy</i> The students will be able to independently extend their knowledge and apply it to new problems.</p>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	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.		
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Geotechnical Engineering: 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		

Course L0807: Basics of Coastal Engineering	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Peter Fröhle
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Basics of planning and design               <ul style="list-style-type: none"> <li>◦ Water levels</li> <li>◦ Currents</li> <li>◦ Waves</li> <li>◦ Ice</li> </ul> </li> <li>• Planning and Design in Coastal Engineering               <ul style="list-style-type: none"> <li>◦ Functional and constructional design</li> <li>◦ Determination of design parameters</li> <li>◦ Design-approaches                   <ul style="list-style-type: none"> <li>▪ Filter</li> <li>▪ Rubble mound constructions</li> <li>▪ Piles</li> <li>▪ Vertical constructions</li> </ul> </li> </ul> </li> </ul>
<b>Literature</b>	Coastal Engineering Manual, CEM  Vorlesungsumdruck

Module Manual M.Sc. "Water and Environmental Engineering"

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

Module M1878: Sustainable energy from wind and water				
Courses				
Title	Typ	Hrs/wk	CP	
Offshore Geotechnical Engineering (L0067)	Lecture	1	1	
Hydro Power Use (L0013)	Lecture	1	1	
Wind Turbine Plants (L0011)	Lecture	2	3	
Wind Energy Use - Focus Offshore (L0012)	Lecture	1	1	
<b>Module Responsible</b>	Dr. Marvin Scherzinger			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Module: Technical Thermodynamics I, Module: Technical Thermodynamics II, Module: Fundamentals of Fluid Mechanics			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe.</p> <p>Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice.</p> <p><i>Skills</i> Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students can discuss scientific tasks sujet-specificly and multidisciplinary within a seminar.</p> <p><i>Autonomy</i> Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.</p>			
<i>Knowledge</i>				
<i>Skills</i>				
<b>Personal Competence</b>				
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	180 min			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: 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 Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: 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 L0067: Offshore Geotechnical Engineering	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Jan Dührkop
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Overview and Introduction Offshore Geotechnics</li> <li>• Introduction to Soil Mechanics</li> <li>• Offshore soil investigation</li> <li>• Focus on cyclical effects</li> <li>• Geotechnical design of offshore foundations</li> <li>• Monopiles</li> <li>• Jackets</li> <li>• Heavyweight foundations</li> <li>• Geotechnical preliminary exploration for the use of lift boats and platforms</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Randolph, M. and Gourvenec, S (2011): Offshore Geotechnical Engineering. Spon Press.</li> <li>• Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London</li> <li>• BSH-Standard Baugrunderkundung für Offshore-Windenergieparks</li> <li>• Lesny K. (2010): Foundations for Offshore Wind Turbines. VGE Verlag, Essen.</li> <li>• EA-Pfähle (2012): Empfehlungen des Arbeitskreises Pfähle der DGGT. Ernst &amp; Sohn, Berlin.</li> </ul>

Course L0013: Hydro Power Use	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Stefan Achleitner
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction, importance of water power in the national and global context</li> <li>• Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies</li> <li>• Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems</li> <li>• Construction of hydroelectric power plants: description of the individual components and their technical system interaction</li> <li>• Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc.</li> <li>• Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection</li> <li>• Hydropower and the Environment</li> <li>• Examples from practice</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage</li> <li>• Quaschnig, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage</li> <li>• Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage</li> <li>• von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage</li> <li>• Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006</li> </ul>

Course L0011: Wind Turbine Plants	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Rudolf Zellermann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Historical development</li> <li>• Wind: origins, geographic and temporal distribution, locations</li> <li>• Power coefficient, rotor thrust</li> <li>• Aerodynamics of the rotor</li> <li>• Operating performance</li> <li>• Power limitation, partial load, pitch and stall control</li> <li>• Plant selection, yield prediction, economy</li> <li>• Excursion</li> </ul>
<b>Literature</b>	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005

Course L0012: Wind Energy Use - Focus Offshore	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Martin Skiba
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering</li> <li>• Physical fundamentals for utilization of wind energy</li> <li>• Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships</li> <li>• Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures</li> <li>• Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection</li> <li>• Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics</li> <li>• Development and planning of offshore wind farms</li> <li>• Operation and optimization of offshore wind farms</li> <li>• Day excursion</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage</li> <li>• Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidelberg, 1997, 3. Auflage</li> <li>• Hau, E.: Windkraftanlagen; Springer, Berlin, Heidelberg, 2008, 4. Auflage</li> <li>• Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage</li> <li>• Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage</li> </ul>

**Module M0827: Modeling in Water Management**

**Courses**

Title	Typ	Hrs/wk	CP
Groundwater Modeling using Modflow (L0543)	Lecture	1	1
Groundwater Modeling using Modflow (L0544)	Recitation Section (small)	2	2
Modeling of Water Supply Network (L0875)	Project-/problem-based Learning	2	3

<b>Module Responsible</b>	Dr. Klaus Johannsen
<b>Admission Requirements</b>	None
<b>Recommended Previous Knowledge</b>	<p>Groundwater</p> <ul style="list-style-type: none"> <li>groundwater hydraulics and transport of substances</li> </ul> <p>Pipe Systems</p> <ul style="list-style-type: none"> <li>Knowledge on urban water infrastructures, in particular drinking water systems and urban drainage systems including special structures</li> <li>Hydraulics of drinking water supply systems and sewer systems</li> <li>Basic knowledge on water management</li> </ul>
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
<i>Knowledge</i>	The students are able to describe the modelling of groundwater flow and transport as well as urban water infrastructures. They can carry out systems analyses and can detect technical and conceptual weak points within the systems in case studies. Besides they are able to analyse interdependencies of hydraulic and toxic phenomena in soil and water.
<i>Skills</i>	The students are able to construct and apply scientific groundwater models independently. They can work on different scenarios and can compare or assess different solutions for existing problems by application of selected software products. The students are able to use different software solutions (e.g. EPANET, EPA-SWMM).
<b>Personal Competence</b>	
<i>Social Competence</i>	Wird nicht vermittelt.
<i>Autonomy</i>	Wird nicht vermittelt.
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70
<b>Credit points</b>	6
<b>Course achievement</b>	None
<b>Examination</b>	Oral exam
<b>Examination duration and scale</b>	30 min
<b>Assignment for the Following Curricula</b>	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 Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory

**Course L0543: Groundwater Modeling using Modflow**

<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Sonja Götz
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Introduction and application of the groundwater model MODFLOW (PMWIN); theoretical background of the model, students do work with the model PMWIN for practical case studies.
<b>Literature</b>	MODFLOW-Handbuch  Chiang, Wen Hsien: PMWIN

<b>Course L0544: Groundwater Modeling using Modflow</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Sonja Götz
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

<b>Course L0875: Modeling of Water Supply Network</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	Mutschmann/Stimmelmayr: Taschenbuch der Wasserversorgung, 16. Auflage. Springer Vieweg - Verlag. Wiesbaden 2014.

Module M0871: Hydrological Systems			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Prof. Peter Fröhle		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Fundamentals of Hydromechanics and Hydraulic Engineering: Hydraulic Engineering I and Hydraulic Engineering II		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students are able to deploy their gained knowledge in applied problems of the hydrology and water management. Additionally, they will be able to work in team with engineers of other disciplines.</p> <p><i>Autonomy</i> The students will be able to independently extend their knowledge and apply it to new problems</p>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	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.		
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory 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 Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory		

Course L0289: Applied Surface Hydrology	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Peter Fröhle
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	Basics of hydrology: <ul style="list-style-type: none"> <li>• Hydrological cycle</li> <li>• Data acquisition</li> <li>• Data analyses and statistical assessment</li> <li>• Statistics of extremes</li> <li>• Regionalization methods for hydrological values</li> <li>• Rainfall-run-off modelling on the basis of a unit hydrograph concepts</li> <li>• Application of rainfall-run-off models on the basis of Kalypso-Hydrology which is an OpenSource Software Tool.</li> </ul>
<b>Literature</b>	<a href="http://de.wikipedia.org/wiki/Kalypso_(Software)">http://de.wikipedia.org/wiki/Kalypso_(Software)</a> <a href="http://kalypso.bjoernsen.de/">http://kalypso.bjoernsen.de/</a> <a href="http://sourceforge.net/projects/kalypso/">http://sourceforge.net/projects/kalypso/</a>

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

<b>Course L0295: Interaction Water - Environment in Fluvial Areas</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Peter Fröhle
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	-

Module M2032: Advanced Vadose Zone Hydrology			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Prof. Nima Shokri		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic knowledge in water and soil Comfortable with math and physics, critical thinking, creative problem solving Analytic skills		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	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		
<i>Skills</i>	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.		
<b>Personal Competence</b>			
<i>Social Competence</i>	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.		
<i>Autonomy</i>	The students will be involved in many problem solving exercises. This will contribute toward their willingness to work independently and responsibly.		
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	Report and Presentation		
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory 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		

Course L2735: Modeling Processes in Vadose Zone	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Mohammad Aziz Zarif
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	Numerical tools will be introduced and used to quantify flow and transport processes in soil
<b>Literature</b>	NA

Course L2732: Vadose Zone Hydrology	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Nima Shokri
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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
<b>Literature</b>	<ul style="list-style-type: none"> <li>- Environmental Soil Physics, by Daniel Hillel</li> <li>- Soil Physics, Sixth Edition, by William A. Jury and Robert Horton</li> <li>- Physical Hydrology, Second Edition, by S. Lawrence Dingman</li> <li>- Introduction to Physical Hydrology, by Martin R. Hendriks</li> </ul>

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

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					
<b>Module Responsible</b>	Prof. Mathias Ernst							
<b>Admission Requirements</b>	None							
<b>Recommended Previous Knowledge</b>	Basic knowledge of water chemistry. Knowledge of the core processes involved in water, gas and steam treatment							
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results							
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> 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.</p> <p><i>Autonomy</i> 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.</p>							
<b>Workload in Hours</b>					Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>					6			
<b>Course achievement</b>					None			
<b>Examination</b>	Written exam							
<b>Examination duration and scale</b>	90 min							
<b>Assignment for the Following Curricula</b>	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 General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Mathias Ernst
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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 electrodialysis, 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.</p> <p>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.</p> <p>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.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• T. Melin, R. Rautenbach: Membranverfahren: Grundlagen der Modul- und Anlagenauslegung (2., erweiterte Auflage), Springer-Verlag, Berlin 2004.</li> <li>• Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, The Netherlands</li> <li>• Richard W. Baker, Membrane Technology and Applications, Second Edition, John Wiley &amp; Sons, Ltd., 2004</li> </ul>

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

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

Module M0822: Process Modeling in Water Technology			
Courses			
Title	Typ	Hrs/wk	CP
Process Modelling of Wastewater Treatment (L0522)	Project-/problem-based Learning	2	3
Process Modeling in Drinking Water Treatment (L0314)	Project-/problem-based Learning	2	3
<b>Module Responsible</b>	Dr. Klaus Johannsen		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Knowledge of the most important processes in drinking water and waste water treatment.		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p>		
<b>Personal Competence</b>	<p><i>Social Competence</i> 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.</p> <p><i>Autonomy</i> Students are able to define a problem, gain the required knowledge and set up a model.</p>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: Elective Compulsory Chemical and Bioprocess Engineering: Technical Complementary Course: 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		

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

<b>Course L0314: Process Modeling in Drinking Water Treatment</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>In the beginning of the course the use of OpenModelica is explained 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.</p>
<b>Literature</b>	<p><b>OpenModelica:</b> <a href="https://openmodelica.org/index.php/download/download-windows">https://openmodelica.org/index.php/download/download-windows</a></p> <p><b>OpenModelica - Modelica Tutorial:</b> <a href="https://openmodelica.org/index.php/useresresources/userdocumentation">https://openmodelica.org/index.php/useresresources/userdocumentation</a></p> <p><b>OpenModelica - Users Guide:</b> <a href="https://openmodelica.org/index.php/useresresources/userdocumentation">https://openmodelica.org/index.php/useresresources/userdocumentation</a></p> <p><b>Peter Fritzson:</b> Principles of Object-Oriented Modeling and Simulation with Modelica 2.1, Wiley-IEEE Press, ISBN 0-471-471631.</p> <p><b>MHW (rev. by Crittenden, J. et al.):</b> Water treatment principles and design. John Wiley &amp; Sons, Hoboken, 2005.</p> <p><b>Stumm, W., Morgan, J.J.:</b> Aquatic chemistry. John Wiley &amp; Sons, New York, 1996.</p> <p><b>DVGW (Hrsg.):</b> Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.</p>

**Module M1123: Selected Topics in Environmental Engineering**

<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Environmental Aquatic Chemistry (L1444)	Lecture	2	3
Solid Matter Process Technology for Biomass (L0052)	Lecture	2	3
Sustainable landfill design and operation (L3270)	Integrated Lecture	3	3
Sludge Treatment (L0520)	Lecture	2	3
Special topics of the Environmental engineering 1CP (L3289)		1	1
Special topics of the Environmental engineering 2CP (L3290)		2	2
Special topics of the Environmental engineering 3CP (L3291)		3	3
Thermal Biomass Utilization (L1767)	Lecture	2	2
Thermal Biomass Utilization (L2386)	Practical Course	1	1
<b>Module Responsible</b>	Prof. Mathias Ernst		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i>			
<b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>			
<b>Workload in Hours</b>	Depends on choice of courses		
<b>Credit points</b>	6		
<b>Assignment for the Following Curricula</b>	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**

<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Dr. Klaus Johannsen
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Concentration and activity</li> <li>• Gas-water partitioning</li> <li>• Acid/base equilibria</li> <li>• Alkalinity and acidity</li> <li>• Precipitation/dissolution equilibria</li> <li>• Redox equilibria</li> <li>• Complex formation</li> <li>• Sorption</li> </ul>
<b>Literature</b>	Worch, E.: Hydrochemistry. Basic Concepts and Exercises. De Gruyter, Berlin, 2015

Course L0052: Solid Matter Process Technology for Biomass	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Werner Sitzmann
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture.
<b>Literature</b>	Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamasse, Springer Verlag, 2001, ISBN 3-540-64853-4  Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe, Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de  Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175

Course L3270: Sustainable landfill design and operation	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Dr. Marco Ritzkowski
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	The course introduces the development of modern waste resource management and demonstrates the importance of landfills in the context of recycling processes. Based on international (EU) and national legislation, the current landfill situation is presented and the future significance of landfills will be discussed. A central element of the course deals with the main transformation processes in the landfilled waste, the emission of gases and leachate, the long-term behaviour of landfills as well as aftercare and after-utilisation measures. Further focal points of the course are measures for the sustainable reduction of environmentally and climate-damaging emissions and aspects of landfill technology in an international context.
<b>Literature</b>	1) <b>Waste Management.</b> Bernd Bilitewski; Georg Härdtle; Klaus Marek (Eds.), ISBN: 9783540592105 , Springer Verlag Lehrbuchsammlung der TUB, Signatur USH-305  2) <b>Solid Waste Technology and Management.</b> Thomas Christensen (Ed.), ISBN: 978-1-4051-7517-3 , Wiley Verlag Lesesaal 2: US - Umweltschutz, Signatur USH-332  3) <b>Solid Waste Landfilling - Concepts, Processes, Technologies.</b> Cossu, R. and Stegmann, R. (Eds.), ISBN: 978-0-12-818336-6  PDF (Volltext) über TUB

Course L0520: Sludge Treatment	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Dr. Joachim Behrendt
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	<b>Tchobanoglous, George</b> (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 <b>Cleverson Vitorio Andreoli, Marcos von Sperling, Fernando Fernandes</b> Sludge Treatment and Disposal ISBN 9781843391661 IWA Publishing, 2007

Course L3289: Special topics of the Environmental engineering 1CP	
<b>Typ</b>	
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Fachtheoretisch-fachpraktische Arbeit
<b>Examination duration and scale</b>	wird zu Beginn der Veranstaltung festgelegt
<b>Lecturer</b>	Dozenten des SD B
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	The course occurs only if required. The content is defined at short notice.
<b>Literature</b>	Die Literatur wird kurzfristig festgelegt.

Course L3290: Special topics of the Environmental engineering 2CP	
<b>Typ</b>	
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Fachtheoretisch-fachpraktische Arbeit
<b>Examination duration and scale</b>	wird zu Beginn der Veranstaltung festgelegt
<b>Lecturer</b>	Dozenten des SD B
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	The course occurs only if required. The content is defined at short notice.
<b>Literature</b>	Die Literatur wird kurzfristig festgelegt.

Course L3291: Special topics of the Environmental engineering 3CP	
<b>Typ</b>	
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Fachtheoretisch-fachpraktische Arbeit
<b>Examination duration and scale</b>	wird zu Beginn der Veranstaltung festgelegt
<b>Lecturer</b>	Dozenten des SD B
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	The course occurs only if required. The content is defined at short notice.
<b>Literature</b>	Die Literatur wird kurzfristig festgelegt.

Course L1767: Thermal Biomass Utilization	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
<b>Examination duration and scale</b>	60 min
<b>Lecturer</b>	Prof. Martin Kaltschmitt
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>The course is structured as follows:</p> <ul style="list-style-type: none"> <li>• Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course</li> <li>• Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste</li> <li>• Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying</li> <li>• Thermo-chemical conversion of solid biofuels <ul style="list-style-type: none"> <li>◦ Basics of thermo-chemical conversion</li> <li>◦ 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</li> <li>◦ Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels</li> <li>◦ 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</li> </ul> </li> <li>• 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)</li> <li>• Bio-chemical conversion of biomass <ul style="list-style-type: none"> <li>◦ Basics of bio-chemical conversion</li> <li>◦ 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</li> <li>◦ Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage</li> </ul> </li> </ul>
<b>Literature</b>	<b>Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage</b>

<b>Course L2386: Thermal Biomass Utilization</b>	
<b>Typ</b>	Practical Course
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Schriftliche Ausarbeitung
<b>Examination duration and scale</b>	Protokolle
<b>Lecturer</b>	Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>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.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- Kaltschmitt, Martin; Hartmann, Hans; Hofbauer, Hermann: Energie aus Biomasse: Grundlagen, Techniken und Verfahren. 3. Auflage. Berlin Heidelberg: Springer Science &amp; Business Media, 2016. -ISBN 978-3-662-47437-2</li> <li>- Versuchsskript</li> </ul>

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	
<b>Module Responsible</b>	Prof. Nima Shokri			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge on water, soil and environmental research.			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module.</p> <p><i>Autonomy</i> 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.</p>			
<i>Knowledge</i>				
<i>Skills</i>				
<b>Personal Competence</b>				
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	Report and Presentation			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Seminar
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Salome Shokri-Kuehni
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Introduction - course objectives, expectations and format</p> <p>Analyzing the Audience, purpose and occasion</p> <p>Constructing and delivering effective technical presentations</p> <p>How to write an abstract</p> <p>How to write a scientific paper</p> <p>Developing competitive and persuasive research proposals</p> <p>Databases and resources available for water and environmental research</p> <p>Individual proposal on water and environmental research</p> <p>Individual project on water and environmental research</p> <p>Presentation on water and environmental research</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9</li> <li>• Supplemental materials and web links which will be available to registered students.</li> </ul>

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

<b>Course L2751: Scientific Communication and Methods</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Nima Shokri
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Introduction - course objectives, expectations and format</p> <p>Analyzing the Audience, purpose and occasion</p> <p>Constructing and delivering effective technical presentations</p> <p>How to write an abstract</p> <p>How to create a scientific poster</p> <p>How to write a scientific paper</p> <p>Developing competitive and persuasive research proposals</p> <p>Individual project (report and presentation) related to soil, water and environmental research</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• The Craft of Scientific Writing Fourth edition Author: Michael Alley Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9</li> <li>• Supplemental materials and web links which will be available to registered students.</li> </ul>

<b>Module M1779: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)</b>				
<b>Courses</b>				
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>	
Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC) (L2926)	Project-/problem-based Learning	4	6	
<b>Module Responsible</b>	Prof. Peter Fröhle			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Hydraulic Engineering</li> <li>• Hydromechanics, Hydraulics</li> <li>• Fundamentals of Coastal Engineering, Coastal- and Flood Protection</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<ul style="list-style-type: none"> <li>• Climate and Climate Change</li> <li>• General Impacts of Climate Change on Wind Regime and Water Cycle</li> <li>• Consequences of Climate Change for Coastal Processes</li> <li>• Coastal Protection in Taiwan and Germany</li> <li>• Fundamentals of Climate Adaptation</li> <li>• Nature-based Solutions (NBS) for Coastal Protection</li> </ul>			
<i>Knowledge</i>				
<i>Skills</i>				
<b>Personal Competence</b>				
<i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Critical thinking: analysis of processes and relations, assessment of needs for action</li> <li>• Creative thinking: development of adaptation strategies and adaptation measures</li> <li>• Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods</li> <li>• Consideration of complex tasks</li> </ul>			
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Working in heterogenous groups</li> <li>• Working in international groups</li> <li>• Working with different scientific / non-scientific disciplines</li> <li>• Self reflection</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written elaboration			
<b>Examination duration and scale</b>	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.			
<b>Assignment for the Following Curricula</b>	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			

<b>Course L2926: Sustainable Nature-based Coastal Protection in a Changing Climate (SeaPiaC)</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Peter Fröhle, Prof. Frank Thorenz
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Climate and Climate Change</li> <li>• General Impacts of Climate Change on Wind Regime and Water Cycle</li> <li>• Consequences of Climate Change for Coastal Processes</li> <li>• Coastal Protection in Taiwan and Germany</li> <li>• Fundamentals of Climate Adaptation</li> <li>• Nature-Based Solutions (NBS) for Coastal Protection</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Materials provided on eLearning Platform (HOOU Platform)</li> <li>• 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.</li> </ul>

Module M1505: Adaptation to Climate Change in Hydraulic Engineering (AKWAS)			
Courses			
Title	Typ	Hrs/wk	CP
Adaptation to climate change in hydraulic engineering (L2291)	Project-/problem-based Learning	4	6
<b>Module Responsible</b>	Prof. Peter Fröhle		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Hydrology, Hydraulic Engineering</li> <li>• Hydromechanic, Hydraulics</li> <li>• Fundamentals of Coastal Engineering, Coastal- and Flood Protection</li> <li>• Hydrological Systems</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>• Climate protection and climate adaptation</li> <li>• Insights into climate change and its regional characteristics - fundamentals, climate modelling / climate models</li> <li>• Impacts of climate change on the components of the regional hydrological cycle</li> <li>• Fundamentals of analysis of climate data</li> <li>• Consequences of the impact of the climate change</li> <li>• Measures for climate adaptation</li> <li>• Assessment, prioritization and communication of adaptation measures</li> <li>• Fundamentals of the analysis of hydrometeorological and hydrological data</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>• Critical thinking: analysis of processes and relations, assessment of needs for action</li> <li>• Creative thinking: development of adaptation strategies and adaptation measures</li> <li>• Practical thinking: inclusion of restrictions, application of calculation approaches, methods, numerical models, planning methods</li> <li>• Consideration of complex tasks</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Working in heterogenous groups</li> <li>• Working with different scientific / non-scientific disciplines</li> <li>• Self reflection</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Application oriented use of knowledge and skills</li> <li>• Autonomous work on complex tasks</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	Preparation of a written report and a presentation of a complex task.		
<b>Assignment for the Following Curricula</b>	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 Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory		

<b>Course L2291: Adaptation to climate change in hydraulic engineering</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Peter Fröhle
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Climate protection and climate adaptation</li> <li>• Findings on climate change and its regional characteristics: fundamentals of climate change, climate modelling / climate models</li> <li>• Impacts of climate change on the components of the regional hydrological cycle(climate science view)</li> <li>• Fundamentals of the analysis of climate data</li> <li>• Consequences of the impacts of climate change (ingenieering science view)</li> <li>• Measures for climate change adaptation</li> <li>• Assessment, prioritization and communication of measures</li> <li>• Fundamentals of analysis of hydrometeorological and hydrological data</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Wird bereitgestellt über die HOOU - eLearning Plattform</li> <li>• abhängig von den jeweils schwerpunktmäßig behandelten Fragestellungen wird das Schrifttum (aktuelle Paper) in der Veranstaltung bzw. über StudIP zur Verfügung gestellt.</li> </ul>

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
<b>Module Responsible</b>	Prof. Peter Fröhle		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Coastal Engineering I		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> 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. Additionally, they will be able to work in team with engineers of other disciplines.</p> <p><i>Autonomy</i> The students will be able to independently extend their knowledge and apply it to new problems.</p>		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	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.		
<b>Assignment for the Following Curricula</b>	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		

<b>Course L0808: Coastal- and Flood Protection</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Peter Fröhle, Prof. Frank Thorenz
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Protection of sandy coasts</p> <ul style="list-style-type: none"> <li>• Sediment transport</li> <li>• Morphology</li> <li>• Technical solution for the protection of sandy coasts                             <ul style="list-style-type: none"> <li>◦ Construction in direction of the coast</li> <li>◦ Constructions perpendicular to the coast</li> <li>◦ Other Concept</li> </ul> </li> <li>• Calculation approaches and numerical models</li> </ul> <p>Flood Protection</p> <ul style="list-style-type: none"> <li>• Classification of constructions / measures</li> <li>• Dikes</li> <li>• Dunes</li> <li>• Foreland - constructions</li> <li>• Flood-Protection Walls</li> <li>• Drainage of the hinterland</li> </ul>
<b>Literature</b>	<p>Vorlesungsumdruck</p> <p>Coastal Engineering Manual CEM</p>

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

<b>Course L1411: Maintenance and Defence of Flood Protection Structures</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Olaf Müller
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Dike protection</li> <li>• Maintenance of flood protection measures</li> </ul>
<b>Literature</b>	Vorlesungsumdruck

Module M2014: Study Work Specialisation Water			
Courses			
Title	Typ	Hrs/wk	CP
<b>Module Responsible</b>	Dozenten des SD B		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	<p>The students are able to demonstrate their detailed knowledge in the field of Water and Environmental Engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society.</p> <p>The students can develop solving strategies and approaches for fundamental and practical problems in the field of Water and Environmental Engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society.</p> <p>Scientific work techniques that are used can be described and critically reviewed.</p>		
<i>Skills</i>	<p>The students are able to independently select methods or planning approaches for the project work and to justify their choice. They can explain how these methods or approaches relate to solutions in the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.</p>		
<b>Personal Competence</b>			
<i>Social Competence</i>	<p>The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.</p>		
<i>Autonomy</i>	<p>The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.</p>		
<b>Workload in Hours</b>	Independent Study Time 360, Study Time in Lecture 0		
<b>Credit points</b>	12		
<b>Course achievement</b>	None		
<b>Examination</b>	Study work		
<b>Examination duration and scale</b>			
<b>Assignment for the Following Curricula</b>	Water and Environmental Engineering: Specialisation Water: Compulsory		

Module M2076: Introduction to Climate Informed Engineering				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Methods in Climate Informed Engineering (L3347)		Lecture	3	3
Topics in Climate Informed Engineering (L3348)		Lecture	3	3
<b>Module Responsible</b>	Prof. Nima Shokri			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Students are expected to have a foundational understanding of environmental science, basic engineering principles, and an interest in sustainability. Recommended knowledge includes climate science, data analysis, and familiarity with engineering design processes. Analytical and critical thinking and creative problem-solving skills are also beneficial			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	This module explores next-generation climate models and high-resolution data, emphasizing their impact on environmental and engineering products and processes. It covers how various engineering disciplines can benefit from climate information. Research-based learning activities, expert talks, and presentations will expose students to state-of-the-art modeling, measurement, and analysis in climate-informed engineering.			
<i>Skills</i>	Climate data analysis, engineering adaptation strategies, problem-solving, research-based learning, and interdisciplinary collaboration.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Collaboration, interdisciplinary teamwork, communication skills, problem-solving, ethical responsibility, and decision-making in climate-resilient engineering.			
<i>Autonomy</i>	Time management, self-directed learning, critical thinking, accountability, initiative, and the ability to conduct independent research and make informed decisions in climate-informed engineering.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	Report and Presentation			
<b>Assignment for the Following Curricula</b>	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 Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Data Science: Specialisation III. Applications: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory Process Engineering: Specialisation Process Engineering: 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 L3347: Methods in Climate Informed Engineering	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Nima Shokri, Prof. Cathy Hohenegger, Prof. Irina Smirnova
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	Students will learn techniques for incorporating climate data and environmental factors into engineering design. It covers climate modelling and the use of sensors and devices to measure climate-related parameters and engineering processes. Students will have the opportunity to conduct their own measurements, analyze the collected data, and write a report on their findings. This hands-on experience will be assessed and contribute to their final grade.
<b>Literature</b>	

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<b>Course L3348: Topics in Climate Informed Engineering</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Irina Smirnova, Prof. Cathy Hohenegger, Prof. Nima Shokri
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	Exploring specific applications of climate data in various engineering disciplines. Invited speakers will present their research and discuss the relevance of climate-informed engineering to their work. Additionally, there will be a segment on effective communication, covering how to give impactful presentations and write research papers. Students will also give presentations on their own class projects related to climate-informed engineering, applying the concepts they've learned. This hands-on experience will be assessed and contribute to their final grade.
<b>Literature</b>	

Module M2156: Water Protection				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Water Protection (L3459)		Integrated Lecture	6	6
<b>Module Responsible</b>	Prof. Simon Michael Papalexiou			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Basic knowledge in water management;</li> <li>• Good knowledge in urban drainage;</li> <li>• Good knowledge of wastewater treatment techniques;</li> <li>• Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties;</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	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.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students can work together in international groups.			
<i>Autonomy</i>	Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	20 %	Presentation	10-minütige Präsentation von Arbeitsergebnissen
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	150 minutes			
<b>Assignment for the Following Curricula</b>	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 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 Environment: Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory			

Course L3459: Water Protection	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	6
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
<b>Lecturer</b>	Prof. Simon Michael Papalexiou
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	
<b>Literature</b>	

Module M2155: Uncertainty Modelling for Engineers				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Uncertainty Modelling for Engineers (L3458)		Integrated Lecture	6	6
<b>Module Responsible</b>	Prof. Simon Michael Papalexiou			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ol style="list-style-type: none"> <li>1. General familiarity with engineering concepts.</li> <li>2. Elementary probability and statistics, and mathematical skills.</li> <li>3. Basic computer skills for handling data.</li> <li>4. Interest in solving engineering problems using statistical and probabilistic methods.</li> </ol>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students will develop a strong foundation in uncertainty, probability, and risk analysis in engineering applications. The course introduces probability as a measure of uncertainty, covering frequency-based methods. Students will explore Bayes' Theorem, probability distributions, extreme value theory, joint probability distributions, and stochastic optimization to model and quantify uncertainty in engineering problems. The course also covers linear and nonlinear regression methods, essential for data-driven decision-making and predictive modeling. Additionally, students will gain insight into risk assessment as a function of probability and disutility and learn how to apply Bayesian Decision Theory to optimize engineering solutions under uncertainty.			
<i>Skills</i>	By the end of the course, students will be able to apply probabilistic models to quantify uncertainty and assess risks in engineering problems. They will gain expertise in fitting probability distributions, performing extreme value analysis, and applying Bayesian inference to real-world engineering challenges. Students will also develop skills in linear and nonlinear regression modeling, enabling them to analyze complex engineering datasets and improve risk predictions. Through hands-on computational exercises, they will learn to implement stochastic methods and optimization techniques to support reliability-based design and engineering decision-making.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students will develop the ability to work collaboratively on engineering risk assessments, communicating technical results effectively with peers, engineers, and decision-makers. They will engage in discussions on risk perception, safety factors, and uncertainty quantification, ensuring that engineering analyses are both rigorous and applicable to real-world infrastructure challenges.			
<i>Autonomy</i>	Students will learn to independently analyze and model engineering uncertainties, selecting and applying appropriate probability distributions, regression methods, and stochastic techniques for various applications. They will also gain the ability to evaluate risks associated with natural and human-made hazards, ensuring they can make informed engineering decisions in design, safety assessment, and disaster mitigation.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	20 %	Presentation	10-minütige Präsentation von Arbeitsergebnissen
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	150 min			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory Environmental Engineering: Core Qualification: Elective Compulsory 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 Water and Environmental Engineering: Specialisation Cities: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Elective Compulsory Water and Environmental Engineering: Specialisation Water: Elective Compulsory			

<b>Course L3458: Uncertainty Modelling for Engineers</b>	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	6
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
<b>Lecturer</b>	Prof. Simon Michael Papalexiou
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Engineering decisions are rarely made with complete certainty—uncertainty affects material properties, environmental conditions, structural performance, and risk assessments. This course provides students with theoretical foundations and practical tools to quantify uncertainty, assess risks, and enhance decision-making in civil, structural, geotechnical, and environmental engineering applications. Students will begin with fundamental probability concepts, learning how Bayes' Theorem, probability distributions, and extreme value theory help evaluate engineering uncertainties. They will explore linear and nonlinear regression methods for analyzing complex datasets, as well as joint probability distributions and stochastic optimization to improve predictive modeling and reliability assessments. The course also introduces Bayesian Decision Theory, offering a structured approach to decision-making under uncertainty. With a focus on real-world engineering problems, students will apply probabilistic models, extreme value analysis, and stochastic techniques to assess risks in infrastructure design, system reliability, and disaster resilience. Hands-on computational exercises will reinforce key concepts, preparing students to work with data-driven models and uncertainty quantification techniques used in engineering practice. This course is ideal for students interested in engineering risk assessment, reliability analysis, and data-driven modeling. By the end of the course, students will have developed critical analytical and problem-solving skills, equipping them for careers in structural safety, geotechnical engineering, environmental risk management, and beyond.</p>
<b>Literature</b>	

**Thesis**

**Module M-002: Master Thesis**

**Courses**

<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
<b>Module Responsible</b>	Professoren der TUHH		
<b>Admission Requirements</b>	<ul style="list-style-type: none"> <li>According to General Regulations §21 (1):</li> </ul> <p>At least 60 credit points have to be achieved in study programme. The examinations board decides on exceptions.</p>		
<b>Recommended Previous Knowledge</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues.</li> <li>The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject, describing current developments and taking up a critical position on them.</li> <li>The students can place a research task in their subject area in its context and describe and critically assess the state of research.</li> </ul>		
<i>Skills</i>	<p>The students are able:</p> <ul style="list-style-type: none"> <li>To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question.</li> <li>To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/or incompletely defined problems in a solution-oriented way.</li> <li>To develop new scientific findings in their subject area and subject them to a critical assessment.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<p>Students can</p> <ul style="list-style-type: none"> <li>Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way.</li> <li>Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressees while upholding their own assessments and viewpoints convincingly.</li> </ul>		
<i>Autonomy</i>	<p>Students are able:</p> <ul style="list-style-type: none"> <li>To structure a project of their own in work packages and to work them off accordingly.</li> <li>To work their way in depth into a largely unknown subject and to access the information required for them to do so.</li> <li>To apply the techniques of scientific work comprehensively in research of their own.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 900, Study Time in Lecture 0		
<b>Credit points</b>	30		
<b>Course achievement</b>	None		
<b>Examination</b>	Thesis		
<b>Examination duration and scale</b>	According to General Regulations		
<b>Assignment for the Following Curricula</b>	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computational Methods and Machine Learning in Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Data Science: Thesis: Compulsory Electrical Engineering and Information Technology: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory		

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Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory  
Logistics, Infrastructure and Mobility: Thesis: Compulsory  
Aeronautics: Thesis: Compulsory  
Mechanical Engineering - Product Development and Production: 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  
Naval Architecture and Ocean Engineering: Thesis: Compulsory  
Ship and Offshore Technology: Thesis: Compulsory  
Theoretical Mechanical Engineering: Thesis: Compulsory  
Process Engineering: Thesis: Compulsory  
Water and Environmental Engineering: Thesis: Compulsory  
Certification in Engineering & Advisory in Aviation: Thesis: Compulsory