TUHH
Hamburg
University of
Technology

# Module Manual

Bachelor of Science (B.Sc.)

# Green Technologies: Energy, Water, Climate
# Dual study program

Cohort: Winter Term 2023

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# Program description

## Content

Climate change, high energy and resource consumption, disruption of ecosystems and a steadily growing world population are the challenges that humanity is already facing today. What the world of tomorrow will look like thus depends decisively on what solutions we find in dealing with these developments.

The degree programme "Green Technologies: Energy, Water, Climate" addresses precisely these issues. By combining specialist knowledge with technical and communication skills, we train engineers who think in an interdisciplinary and solution-oriented way. The focus is on "green" technologies for a sustainable, climate and resource-friendly energy and water supply.

In the first three semesters, the focus is on learning the basics of mathematics, mechanics, chemistry, computer science, thermodynamics as well as meteorology and climate. In the further course, the study programme is then expanded to include basic engineering subjects and the topics of regenerative energies as well as water supply and treatment. From the fourth semester onwards, you can choose a subject focus according to your personal interests. You can choose from the four specialisations "Energy Systems", "Water", "Bioresource Technology" or "Energy Technology".

And of course you can also start a Master's programme. The specialisations of the Bachelor's programme are compiled and coordinated in such a way that you are optimally prepared for a further Master's programme and a seamless transition to subsequent Master's programmes at TU Hamburg is made possible.

The study programme "Green Technologies: Energy, Water, Climate" offers an engineering education in the energy-water-climate nexus that is unique in Germany. To this end, the study programme combines the competences of energy technology, process technology and sustainable supply and disposal engineering with natural science disciplines.
With the Bachelor's degree, you acquire your first academic degree that qualifies you for a profession and you become an engineer. You can already start your professional life.

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

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

## Career prospects

The study programme Green Technologies: Energy, Water, Climate trains engineers for whom there will be a high demand today and in the future. The spectrum of employers ranges from engineering and planning offices, energy suppliers and water supply and disposal companies to industrial companies and public authorities, but also research institutions.

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

## Learning target

The bachelor's degree programme Green Technologies: Energy, Water, Climate is designed to prepare students both for a professional activity and for a relevant consecutive master's degree programme. The basic methodological knowledge required for this is acquired during the study programme. The learning objectives of the degree programme are achieved through an interplay of basic and advanced modules from mechanical engineering, process engineering, hydraulic engineering and renewable energies.
Through the participation of professional engineers from industry in lectures, through experimental laboratory practicals and the exchange with lecturers from the University of Hamburg in the field of climate and meteorology, the students are able to develop a realistic relationship to the diverse professional field of climate, environmental, water and energy technology during their studies. This significantly increases the graduates' later career opportunities and enables them to help shape our world of tomorrow.
Graduates will be able to responsibly and competently perform an engineering job in various fields of activity in green and future-oriented technologies. In addition, they acquire the necessary scientific knowledge for a subsequent, in-depth Master's degree, which can be studied consecutively based on the chosen specialisation.

**Knowledge**

The knowledge acquired during the study programme enables graduates to understand the phenomena occurring in the subject areas of green technologies and related disciplines. They have understood the basic principles of climate, urban water management, conventional and renewable energy systems, with particular reference to sustainability and environmental protection. Knowledge is constituted by facts, principles and theories and is acquired in the Bachelor's degree programme Green Technologies in the following areas:
- Graduates are able to reproduce basic knowledge in the scientific and engineering fields of mathematics, chemistry, mechanics, thermodynamics, fluid mechanics, computer science, electrical engineering, control engineering and heat and mass transfer.
- Graduates are able to outline and discuss fundamental methods and procedures for solving or approximating iterative decision and optimisation problems, such as differentiation, gradient-based procedures, testing hypotheses, as well as their analysis in terms of complexity, convergence and goodness.
- Through further specialised knowledge of the subject area (energy systems, water, bioresource technology or energy technology), they can further deepen their learned content with a focus on climate and environmental impact and develop procedures for solving environmental issues.
- Graduates are able to describe the construction, operation and organisation of conventional and regenerative energy plants and their components, including the control concepts used in the process. They are able to recognise the challenges of the energetically and economically optimised operation of energy plants, taking into account the additional criteria of resource conservation, sustainability, environmental compatibility and economic efficiency.
- Graduates will be able to investigate suitable technical alternatives in their professional life in order to minimise the environmental and social footprint of their engineering work and effectively support the energy transition.
- Graduates will be able to gain knowledge and skills beyond engineering for their profession through non-technical events.

**Skills**

The ability to apply learned knowledge to solve specific problems is supported in many ways in the Bachelor's degree programme Green Technologies:
- Graduates are able to master relevant, specialised methods and tools, to assess their predictability and complexity and to implement them using suitable programming tools from current practice.

- Graduates are able to understand and further analyse climate processes, describe facilities and processes in the field of green technologies, balance energy systems and identify technical as well as economic relationships between conventional and renewable energy technologies.
- Graduates can identify and describe environmental impacts in general and develop control strategies of environmental pollution from industrial plants. This is also based on experience from related fields of measurement technology and process and environmental engineering.
- Graduates have the ability to identify the objectives of an engineering project, a green technology operation or society for a balanced and sustainable coverage of energy, water and resource needs and to responsibly prioritise in finding the optimal solution approach.

- Graduates are able to present the approach and results of their work in writing and explain them orally. They have mastered presentation techniques and have practised technical communication.
- Graduates are able to independently plan and conduct experiments and interpret the results.
- Graduates are able to apply measurement, control and regulation technology or constructive methods.
- Graduates have the ability to develop designs for processes, machines and apparatus according to specified requirements.

**Social competence**

Social competence includes the individual ability and willingness to work together with others in a goal-oriented manner, to understand the interests of others, to communicate and to help shape the working and living environment.
- Graduates can organise themselves in a professionally homogeneous team, work out a solution, take on specific subtasks and responsibly deliver partial results, and reflect on their own contribution.
- Graduates are able to discuss their scientific work results interactively and interdisciplinarily, to present them in front of the plenum and to defend them.
- Graduates are able to communicate about the contents and problems of energy and environmental technology with experts and laypersons.

Independence

Personal competences include not only the competence to act independently, but also to further develop one's own ability to act.
- Graduates can independently explore a narrowly defined sub-area of green technologies and summarise the results in detail in a presentation using common presentation techniques or in an essay of several pages. Critical analysis and not mere memorisation is required.
- Graduates are able to realistically assess their existing competences and work on deficits independently.
- Graduates are able to organise and carry out projects independently.
- Graduates are able to work independently on subject-specific sub-projects in a Bachelor's thesis using what they have learned during their studies.
- Graduates are able to independently obtain necessary information from suitable literature sources and to assess their quality.
- Graduates are able to evaluate technical problems in a larger social context and assess the non-technical effects of engineering activities.

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

## Program structure

The curriculum of the Bachelor's degree programme Green Technologies: Energy, Water, Climate, which was designed as an undergraduate degree programme, consists mainly of compulsory courses. Elective options are provided for in the supplementary courses of the non-technical area.
In the first three semesters, the focus is on learning basic knowledge in the areas of mathematics, mechanics, chemistry, computer science, thermodynamics as well as meteorology and climate. Furthermore, the topics and applications of green technologies are taught in a module strand "Green Technologies" in the first, third and fifth semesters.
In the further course, the study programme is then expanded to include basic engineering subjects and the topics of regenerative energies as well as water supply and treatment. From the fourth semester onwards, you can choose a subject focus according to your personal interests. You can choose from the four specialisations "Energy Systems", "Water", "Bioresource Technology" or "Energy Technology".
Structure of the degree programme:
- Mathematical-scientific basics (five modules)
- Fundamentals of engineering (ten modules)
- Green Technologies: Fundamentals of Climate and Environmental Engineering (three modules)
- Engineering Applications in Water and Energy (three modules).
- Electives in the specialisations "Energy Systems", "Water", "Bioresource Technology" or "Energy Technology" (five modules)

The following content from the non-technical area is added:
- One module on business administration
- Further supplementary courses from the non-technical compulsory elective catalogue (one module)

The scope of the Bachelor's programme in Energy and Environmental Engineering thus comprises 28 modules. These are divided into 26 subject modules and two non-technical supplementary modules. The programme is based on a broad mathematical-physical and scientific foundation. It also ensures that the theoretical basic knowledge is deepened and applied in the subjects of green technologies and engineering applications. In addition, the Bachelor's thesis is the module that concludes the degree programme.

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

## Core Qualification

Graduates have acquired a basic knowledge of the natural sciences and engineering in the fields of mathematics, climate and meteorology, chemistry, mechanics and thermodynamics and materials science. It enables them to understand the phenomena occurring in energy technology, environmental technology and related disciplines. They have understood the basic principles of urban water management and conventional and renewable energy pulse transport processes, with particular reference to sustainability. They are familiar with measurement, control and regulation technology and design methods. Furthermore, the students have gained a comprehensive knowledge in the field of green technologies.
Graduates are able to
- identify, abstract, formulate and holistically solve technical problems in a fundamentally oriented manner;
- penetrate, analyse and evaluate processes and methods of their discipline on a systems engineering basis;
- select and apply appropriate methods of analysis, modelling, simulation and optimisation;
- conduct literature research and use databases and other sources of information for their work;
- plan and conduct experiments independently and interpret the results;
- successfully complete a Master's degree in green technologies with in the field of process engineering, mechanical engineering or civil engineering.

Graduates can responsibly and competently carry out an engineering activity in various fields of activity of climate, environmental and resource-saving technologies and and become the right to carry the professional title of "Engineer" along the lines of the engineering regulations of the German Federal Lands (IngG).

### Module M0850: Mathematics I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Mathematics I (L2970) | Lecture | 4 | 4 |
| Mathematics I (L2971) | Recitation Section (large) | 2 | 2 |
| Mathematics I (L2972) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Anusch Taraz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | School mathematics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can name the basic concepts in analysis and linear algebra. They are able to explain them using appropriate examples.<br>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.<br>• They know proof strategies and can reproduce them. |
| *Skills* | • Students can model problems in analysis and linear algebra with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods.<br>• Students are able to discover and verify further logical connections between the concepts studied in the course.<br>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to work together in teams. They are capable to use mathematics as a common language.<br>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers. |
| *Autonomy* | • Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.<br>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems. |
| **Workload in Hours** | Independent Study Time 128, Study Time in Lecture 112 |
| **Credit points** | 8 |
| **Course achievement** | Compulsory: Yes; Bonus: 10 %; Form: Excercises; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory |

| | |
|---|---|
| | Computer Science in Engineering: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| **Course L2970: Mathematics I** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Lecturer** | Prof. Anusch Taraz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Mathematical Foundations:<br><br>sets, statements, induction, mappings, trigonometry<br><br>Analysis: Foundations of differential calculus in one variable<br><br>• natural and real numbers<br>• convergence of sequences and series<br>• continuous and differentiable functions<br>• mean value theorems<br>• Taylor series<br>• calculus<br>• error analysis<br>• fixpoint iteration<br><br>Linear Algebra: Foundations of linear algebra in $R^n$<br><br>• vectors: rules, linear combinations, inner and cross product, lines and planes<br>• systems of linear equations: Gauß elimination, linear mappings, matrix multiplication, inverse matrices, determinants<br>• orthogonal projection in R^n, Gram-Schmidt-Orthonormalization |
| **Literature** | • T. Arens u.a. : Mathematik, Springer Spektrum, Heidelberg 2015<br>• W. Mackens, H. Voß: Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994<br>• W. Mackens, H. Voß: Aufgaben und Lösungen zur Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994<br>• G. Strang: Lineare Algebra, Springer-Verlag, 2003<br>• G. und S. Teschl: Mathematik für Informatiker, Band 1, Springer-Verlag, 2013 |

| **Course L2971: Mathematics I** | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anusch Taraz, Dr. Dennis Clemens, Dr. Simon Campese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| **Course L2972: Mathematics I** | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anusch Taraz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1802: Engineering Mechanics I (Stereostatics)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Engineering Mechanics I (Statics) (L1001) | Lecture | 2 | 3 |
| Engineering Mechanics I (Statics) (L1003) | Recitation Section (large) | 1 | 1 |
| Engineering Mechanics I (Statics) (L1002) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Benedikt Kriegesmann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Solid school knowledge in mathematics and physics. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can<br>• describe the axiomatic procedure used in mechanical contexts;<br>• explain important steps in model design;<br>• present technical knowledge in stereostatics. |
| *Skills* | The students can<br>• explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems;<br>• apply basic statical methods to engineering problems;<br>• estimate the reach and boundaries of statical methods and extend them to be applicable to wider problem sets. |
| **Personal Competence** | |
| *Social Competence* | The students can work in groups and support each other to overcome difficulties. |
| *Autonomy* | Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Data Science: Specialisation II. Application: Elective Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| Course L1001: Engineering Mechanics I (Statics) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Benedikt Kriegesmann |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Tasks in Mechanics<br>• Modelling and model elements<br>• Vector calculus for forces and torques<br>• Forces and equilibrium in space<br>• Constraints and reactions, characterization of constraint systems<br>• Planar and spatial truss structures<br>• Internal forces and moments for beams and frames<br>• Center of mass, volumn, area and line<br>• Computation of center of mass by intergals, joint bodies<br>• Friction (sliding and sticking)<br>• Friction of ropes |
| **Literature** | K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009).<br>D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1. 11. Auflage, Springer (2011). |

| Course L1003: Engineering Mechanics I (Statics) | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Benedikt Kriegesmann |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Forces and equilibrium<br>Constraints and reactions<br>Frames<br>Center of mass<br>Friction<br>Internal forces and moments for beams |
| **Literature** | K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009).<br>D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1. 11. Auflage, Springer (2011). |

| Course L1002: Engineering Mechanics I (Statics) | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Benedikt Kriegesmann |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Forces and equilibrium<br>Constraints and reactions<br>Frames<br>Center of mass<br>Friction<br>Internal forces and moments for beams |
| **Literature** | K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009).<br>D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1. 11. Auflage, Springer (2011). |

## Module M0883: General and Inorganic Chemistry

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| General and Inorganic Chemistry (L0824) | Lecture | 3 | 3 |
| Fundamentals in Inorganic Chemistry (L0996) | Practical Course | 3 | 2 |
| Fundamentals in Inorganic Chemistry (L1941) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Gerrit A. Luinstra |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | High School Chemistry/Physics/calculus, specifically Structure of the atom with electrons, Free energy G, concepts of pH and redox processes, electric circuits (potential and resistance), calculus with logarithms. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to handle molecular orbital theory including the octahedral ligand field, qualitatively describe the resulting electron density distribution and structures of molecules (VSEPR); they have developed an idea of molecular interactions in the gas, liquid and solid phases. They are able to describe chemical reactions in the sense of retention of mass and energy, enthalpy and entropy as well as the chemical equilibrium. They can explain the concept of activation energy in conjucture with particle kinetic energy. They have increased knowledge of acid-base concepts, acid-base reactions in water, can perform pH calculations, understand titration as a quantitative analysis. They can recognize redox processes, correlate redox potentials to Gibbs energy, handle Nernst theory in describing the concentration dependence of redox potentials, known the concept of overpotential and understand corrosion as a redox reaction (local element). |
| *Skills* | Students are able to use general and inorganic chemistry for the design of technical processes. Especially they are able to formulate mass and energy balances and by this to optimise technical processes. They are able to perform simple calculations of pH values in regard to an application of acids and bases, and evaluate the course of redox processes (calculation of redoxpotentials). They are able to transform a verbal formulated message into an abstract formal procedure. Students are able to present and discuss their scientific results in plenum. The students are able to document the results of their experiments scientifically. They are able to use scientific citation methods in their reports. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss given tasks in small groups and to develop an approach.<br>Students are able to carry out experiments in small groups in lab scale and to distribute tasks in the group independently. |
| *Autonomy* | Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.<br>Students are able to apply their knowledge to plan, prepare and conduct experiments. Students are able to independently judge their own knowledge and to acquire missing knowledge that is required to fulfill their tasks. |
| **Workload in Hours** | Independent Study Time 82, Study Time in Lecture 98 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: Yes; Bonus: None; Form: Subject theoretical and practical work; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0824: General and Inorganic Chemistry | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Gerrit A. Luinstra |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | This elementary course in chemistry comprises the following four topics, i) molecular orbital theory applied to compounds with bonds between s-, p- and d-block elements (octahedral field only), Description of molecular interactions in the gas, liquid and solid phase, (semi) conductivity on account of the formation of band structures, ii) describing chemical reactions in the sense of retention of mass and energy, enthalpy and entropy, chemical equilibrium, concepts of activation energy in conjucture with particle kinetic energy iii) acid-base concepts, acid-base reactions in water, pH calculation, quantitative analysis (titration) iv), redox processes in water, redox potential, Nernst theory describing the concentration dependence of redox potentials, overpotential, corrosion (local elments). |
| **Literature** | Chemie für Ingenieure, Guido Kickelbick, ISBN 978-3-8273-7267-3<br>Chemie, Charles Mortimer (Deutsch und Englisch verfügbar)<br>http://www.chemgapedia.de |

| Course L0996: Fundamentals in Inorganic Chemistry | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 3 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 18, Study Time in Lecture 42 |
| **Lecturer** | Prof. Gerrit A. Luinstra |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | This laboratory course comprises the following four topics, i) atomic structure and application of spectroscopic methods, introduction of analytic methods ii) chemical reactions (qualitative analysis), bonding types, reaction types, reaction equations iii) acid-base concepts, acid-base reactions in water, buffer solution, quantitative analysis (titration) iv), redox processes in water, redox potential, Nernst theory describing the concentration dependence of redox potentials, galvanic elements and electrolysis.<br>Prior to every experiement, a seminar takes place in small groups (12-15 students). The students participate orally. Team work and cooperation are forwarded because the experiments in the lab and the writing of the reports is conducted in groups of three or four students. Additionally, acedemic writing conveyed (documentation of experiment results in lab journals, literature citations in reports). |
| **Literature** | Chemie für Ingenieure, Guido Kickelbick, ISBN 978-3-8273-7267-3<br>Chemie, Charles Mortimer (Deutsch und Englisch verfügbar)<br>Analytische und anorganische Chemie, Jander/Blasius<br>Maßanalyse, Jander/Jahr |

| Course L1941: Fundamentals in Inorganic Chemistry | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Gerrit A. Luinstra |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | This course has 4 major parts: i) decribing molecules and solids of the s-, p- and d-elements of the periodic table in terms of orbital theory (only octahedral field), interactions between molecules in all phases; ii) description of chemical reactions in context of concentrations, mass and energy balance (enthalpy and entropy), kinetics and concepts of activation energy; iii) acid-base concepts according to Lewis and Brönsted, pH measurement and calculations, titration; iv) redox reactions in water, redox potential and Nernst equation, overpotentials and local elements in the matter of corrosion. |
| **Literature** | Chemie für Ingenieure, Guido Kickelbick, ISBN 978-3-8273-7267-3<br />Chemie, Charles Mortimer (Deutsch und Englisch verfügbar)<br />http://www.chemgapedia.de</p> |

## Module M1692: Computer Science for Engineers - Introduction and Overview

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Computer Science for Engineers - Introduction and Overview (L2685) | Lecture | 3 | 3 |
| Computer Science for Engineers - Introduction and Overview (L2686) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Görschwin Fey |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Elementary knowledge of programming as taught in the "Introduction to Programming" bridge course or school. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The module provides prospective engineers with an overview of computer science as a discipline and of the fundamentals of programming. The aim is to facilitate the exchange between engineers and computer scientists and to show possibilities and limitations of programmable systems.<br><br>Basic knowledge is learned about<br><br>• approaches for estimating runtime and memory requirements<br>• computer architecture<br>• automata theory<br>• simple data structures like lists and fields<br>• sorting algorithms<br>• programming<br>• modeling for software<br>• unit testing testing and debugging |
| *Skills* | Basic programming skills are learned. Students can<br><br>• describe basic components of a computer<br>• select appropriate data structures for a problem solution<br>• design and implement simple programs<br>• apply unit testing<br>• estimate the runtime and memory requirements of simple algorithms |
| **Personal Competence** | |
| *Social Competence* | Students are able to develop and communicate computer science solutions in small multidisciplinary project teams. |
| *Autonomy* | Students can independently create small programs to solve simple problems and validate their correctness. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>No / 10 % / Attestation / Testate finden semesterbegleitend statt. |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

### Course L2685: Computer Science for Engineers - Introduction and Overview

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Görschwin Fey |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | • Informatik<br>  ◦ Helmut Herold, Bruno Lurz, Jürgen Wohlrab, Matthias Hopf: Grundlagen der Informatik, 3. Auflage, 816 Seiten, Pearson Studium, 2017.<br>• C++<br>  ◦ Bjarne Stroustrup, Einführung in die Programmierung mit C++, 479 Seiten, Pearson Studium, 2010.<br>  --> in der englischen Version bereits eine neuere Auflage!<br>  ◦ Jürgen Wolf : Grundkurs C++: C++-Programmierung verständlich erklärt, Rheinwerk Computing, 3. Auflage, 2016. |

| Course L2686: Computer Science for Engineers - Introduction and Overview | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Görschwin Fey |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1711: Green Technologies I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction Green Technologies (L2727) | Seminar | 2 | 2 |
| Meteorology and Climate Systems - Introduction (L2726) | Lecture | 2 | 2 |
| Meteorology and Climate Systems - Introduction (L2829) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Upon completion of this module, students will be able to describe and critically evaluate current environmental and climate problems, especially in Hamburg. Furthermore, they are able to find and process suitable approaches to solutions. The students can compare learned technologies in the field of climate and environmental protection, develop and take a standpoint on them and defend it in discussions.<br><br>In addition, students can give an overview of the basics of meterology and climate. |
| *Skills* | The students are able to apply the knowledge they have acquired on sustainable technologies in the area of the environmentally and climate-friendly water, energy and climate nexus in order to explain solution approaches for a supply-secure provision.<br><br>Furthermore, the students are able to explain the procedures and basics on the topics of climate and meterology and apply them to renewable energy projects in the context of other modules. |
| **Personal Competence** | |
| *Social Competence* | Students can<br>• work together in a team of about 3-5 people,<br>• discuss tasks on the topics of environmental, resource and climate protection in a subject-specific manner and develop joint solutions,<br>• present their own work results to fellow students and<br>• assess the performance of fellow students in comparison to their own performance and deal with feedback on their own performance. |
| *Autonomy* | The students are able to independently access sources about the question to be worked on. They are able to assess their respective learning status in consultation with supervisors and, on this basis, define further questions and the work steps necessary to solve them. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** None; **Form** Presentation; **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory |

### Course L2727: Introduction Green Technologies

| | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Preliminary discussion of the seminar<br>• Interesting presentations by people responsible for climate and environmental protection in Hamburg, keyword: Green Port of Hamburg<br>• Handing out of topics and tasks from the area of the seminar topic (green port of Hamburg) to individual students / groups of students (depending on the number of participating students<br>• Presentation of the task / the topic to be worked on with PPT presentation or poster presentation of the results |
| **Literature** | Eigenständiges Literaturstudium in der Bibliothek und aus anderen Quellen. |

| Course L2726: Meteorology and Climate Systems - Introduction | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Raphaela Vogel, Prof. Stefan Bühler |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | **The Earth's energy balance**<br>Conservation of energy, radiation, greenhouse effect, radiation balance, radiative forcing<br>**Local climate**<br>Energy balance at the surface, canopy effects (vegetation, city, ...), topography effects, evaporation, role of the pedosphere<br>**The water cycle**<br>Reservoirs of water, Clausius-Clapeyron, hydrological sensitivity, extreme precipitation<br>**The vertical structure of the atmosphere**<br>Hydrostatics, stability, spheres and pauses, radiative-convective equilibrium<br>**Clouds**<br>Life cycle of a cloud, from water vapour to precipitation<br>**A windy planet**<br>Pressure gradient force, Coriolis force, global wind system, turbulence and log. wind profile Wind profile<br>**Climate sensitivity**<br>Forcing-response approach, climate sensitivity, methods of determination, current knowledge<br>**Synoptics**<br>High and low pressure areas, air masses and fronts, instabilities<br>**Fast feedbacks in climate**<br>Water vapour, temperature gradient, ice albedo, clouds<br>**Weather and climate modelling**<br>Discretisation and num. Solution, parametrisation, data assimilation, boundary conditions, ensemble predictions, chaos, parallel computers<br>**Carbon cycle and earth history**<br>Reservoirs of carbon, fossil fuels, earth ages, Urey reaction<br>**Weather extremes**<br>Rain, wind and heat - meteorological basics, statistical description & climate trends<br>**Ice and sea level**<br>Is the sea level rising? Role of ice in Earth's history, snowballs and greenhouses, Milankovitch cycles<br>**The view from space** |
| **Literature** | Folien aus Vorlesung |

| Course L2829: Meteorology and Climate Systems - Introduction | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Raphaela Vogel, Prof. Stefan Bühler |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | **The Earth's energy balance**<br>Conservation of energy, radiation, greenhouse effect, radiation balance, radiative forcing<br>**Local climate**<br>Energy balance at the surface, canopy effects (vegetation, city, ...), topography effects, evaporation, role of the pedosphere<br>**The water cycle**<br>Reservoirs of water, Clausius-Clapeyron, hydrological sensitivity, extreme precipitation<br>**The vertical structure of the atmosphere**<br>Hydrostatics, stability, spheres and pauses, radiative-convective equilibrium<br>**Clouds**<br>Life cycle of a cloud, from water vapour to precipitation<br>**A windy planet**<br>Pressure gradient force, Coriolis force, global wind system, turbulence and log. wind profile Wind profile<br>**Climate sensitivity**<br>Forcing-response approach, climate sensitivity, methods of determination, current knowledge<br>**Synoptics**<br>High and low pressure areas, air masses and fronts, instabilities<br>**Fast feedbacks in climate**<br>Water vapour, temperature gradient, ice albedo, clouds<br>**Weather and climate modelling**<br>Discretisation and num. Solution, parametrisation, data assimilation, boundary conditions, ensemble predictions, chaos, parallel computers<br>**Carbon cycle and earth history**<br>Reservoirs of carbon, fossil fuels, earth ages, Urey reaction<br>**Weather extremes**<br>Rain, wind and heat - meteorological basics, statistical description & climate trends<br>**Ice and sea level**<br>Is the sea level rising? Role of ice in Earth's history, snowballs and greenhouses, Milankovitch cycles<br>**The view from space** |
| **Literature** | Folien aus Übung |

| Module M1755: Linking theory and practice (dual study program, Bachelor's degree) | |
|---|---|
| **Module Responsible** | Dr. Henning Haschke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students...<br>... can describe and classify selected classic and modern theories, concepts and methods<br>• related to self-management, and organising work and learning<br>• self-competence and<br>• social skills<br>... and apply them to specific situations, projects and plans in a personal and professional context. |
| *Skills* | Dual students...<br>• ... anticipate typical difficulties, positive and negative effects, as well as success and failure factors in the engineering sector, evaluate them and consider promising strategies and courses of action. |
| **Personal Competence** | |
| *Social Competence* | Dual students...<br>• ... work together in a problem-oriented and interdisciplinary manner as part of expert and work teams.<br>• ... are able to assemble and lead working groups.<br>• ... present complex, subject-related solutions to problems to experts and stakeholders and can develop these further together. |
| *Autonomy* | Dual students...<br>• ... define, reflect and evaluate goals for learning and work processes.<br>• ... design their learning and work processes independently and sustainably at the university and company.<br>• ... take responsibility for their learning and work processes.<br>• ... are able to consciously think through their ideas or actions and relate them to their self-image to develop conclusions for future action based on this. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Studienbegleitende und semesterübergreifende Dokumentation: Die Leistungspunkte für das Modul werden durch die Anfertigung eines digitalen Lern- und Entwicklungsberichtes (E-Portfolio) erworben. Dabei handelt es sich um eine fortlaufende Dokumentation und Reflexion der Lernerfahrungen und der Kompetenzentwicklung im Bereich der Personalen Kompetenz. |

| Course L2885: Self-Competence for Professional Success in Engineering (for Dual Study Program) | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Henning Haschke, Heiko Sieben |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | • Key qualifications for professional success<br>• Personality and self-image<br>• Personality profiles<br>• Emotional competence<br>• Needs structure models<br>• Motivation theories and models<br>• Communication basics, communication problems<br>• Conflict management<br>• Constructive communication and language cultures<br>• Resilience<br>• Transfer skills and (self-)reflection<br>• Intercultural competence and business etiquette<br>• Documenting and reflecting on learning experiences |
| **Literature** | Seminarapparat |

| Course L2884: Self-Management, Organising Work and Learning in Engineering (for Dual Study Program) | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Henning Haschke, Heiko Sieben |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | • Learning to learn<br>• Instruments and methods for time and self-management<br>• Personality and work style/behaviour (DISC model); inner drivers/motivation<br>• Goal setting and planning techniques (SMART, GROW); for short-, medium- and long-term planning<br>• Creativity techniques<br>• Stress management, resilience<br>• (Self-)reflection throughout the learning and work process<br>• Structuring/connecting learning and work processes within different learning environments<br>• Factors influencing learning transfer/transfer skills<br>• Documenting and reflecting on learning experiences |
| **Literature** | Seminarapparat |

| Course L2886: Social-Competence: Team Development and Communication in Engineering (for Dual Study Program) | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Henning Haschke, Heiko Sieben |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | • Forms, conditions and processes of working groups and leadership relationships<br>• Social skills: theories and models<br>• Communication and discussion techniques<br>• Empathy and motivation in teamwork, the way teams work<br>• Critical ability<br>• Team development: ways of developing working and project groups<br>• Insights into day-to-day leadership: theories and models, leadership tasks, leadership styles, situational leadership, basics of change management<br>• Documenting and reflecting on learning experiences |
| **Literature** | Seminarapparat |

## Module M1750: Practical module 1 (dual study program, Bachelor's degree)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical term 1 (dual study program, Bachelor's degree) (L2879) | | 0 | 6 |

| | |
|---|---|
| **Module Responsible** | Dr. Henning Haschke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | A: Self-management, organising work and learning in engineering (for dual study program) |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students...<br>• ... describe their employer's organisation (company) and the associated regulations that relate to how tasks and competences are distributed, as well as how work processes are handled.<br>• ... understand the structure and objectives of the dual study programme and the increasing requirements throughout the course of study. |
| *Skills* | Dual students...<br>• ... use equipment and resources professionally in accordance with the assigned work areas and tasks, and describe operational processes and procedures with regard to the intended work results/objectives.<br>• ... implement the university's application recommendations in relation to their current tasks. |
| **Personal Competence** | |
| *Social Competence* | Dual students...<br>• ... have familiarised themselves with their new working environment (learning environment) and the associated tasks/processes/working relationships.<br>• ... know their central points of contact and company colleagues, and exchange ideas with them constructively.<br>• ... coordinate work tasks with their professional supervisor and ask for support as needed.<br>• ... help shape the work in the assigned work area and offer their colleagues support to complete their work.<br>• ... work together with others in smaller work teams in a result-oriented manner. |
| *Autonomy* | Dual students...<br>• ... structure their work and learning processes within the company independently in line with their responsibilities and authorisations, and coordinate them with their professional supervisor.<br>• ... complete work tasks/assignments with the support of colleagues.<br>• ... coordinate the practical phase with any individual preparation required for the examination phase at TUHH.<br>• ... document and reflect on how their foundational subjects link with their work as an engineer. |
| **Workload in Hours** | Independent Study Time 180, Study Time in Lecture 0 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase. |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Computer Science: Core Qualification: Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Engineering Science: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| Course L2879: Practical term 1 (dual study program, Bachelor's degree) | |
|---|---|
| **Typ** | |
| **Hrs/wk** | 0 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 180, Study Time in Lecture 0 |
| **Lecturer** | Dr. Henning Haschke |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | **Company onboarding process**<br>• Assigning initial work areas (supervisor, colleagues)<br>• Assigning a contact person within the company (usually the HR department)<br>• Assigning a professional mentor in the work area (relating to practical application)<br>• Responsibilities and authorisations of the dual student within the company<br>• Supporting/working with colleagues<br>• Scheduling the relevant practical modules with initial work tasks<br>• Theory/practice transfer options<br>• Scheduling the examination phase/subsequent study semester<br>**Operational knowledge and skills**<br>• Company-specific: organisational structure, corporate strategy, business and work areas, work procedures and processes, operational levels<br>• Process and procedure options within the labour-market-relevant field of engineering<br>• Operational equipment and resources<br>• Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company<br>**Sharing/reflecting on learning**<br>• Creating an e-portfolio<br>• Relevance of foundational subjects when working as an engineer<br>• Comparing the learning and working processes of different learning environments with regard to their results and effects |
| **Literature** | • Studierendenhandbuch<br>• Betriebliche Dokumente<br>• Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer |

## Module M0888: Organic Chemistry

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Organic Chemistry (L0831) | Lecture | 2 | 2 |
| Organic Chemistry (L0832) | Practical Course | 2 | 2 |
| Organic Chemistry (L3184) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Nina Schützenmeister |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | High School Chemistry and/or lecture "general and inorganic chemistry" |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are familiar with basic concepts of organic chemistry. They are able to classify organic molecules and to identify functional groups and to describe the respective synthesis routes. Fundamental reaction mechanisms like nucleophilic substitution, eliminations, additions and aromatic substitution can be described. Students are capable to describe in general modern reaction mechanisms. |
| *Skills* | Students are able to use basics of organic chemistry for the design of technical processes. Especially they are able to formulate basic routes to synthesize small organic molecules and by this to optimise technical processes in Process Engineering. They are able to transform a verbally formulated message into an abstract formal procedure.<br>The students are able to document and interpret their working process and results scientifically. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss in small groups and develop an approach for given tasks. |
| *Autonomy* | Students are able to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / None / Subject theoretical and practical work |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory |

### Course L0831: Organic Chemistry

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Nina Schützenmeister, Robert Meyer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The lecture covers basic concepts of organic chemistry. This includes simple carbon compounds, alkanes, alkenes, aromatic compounds, alcohols, phenols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, amides and amino acids. Further, fundamentals of reaction mechanisms will be described. This includes nucleophilic substitution, eliminations, additions and aromatic substitution. Also modern reaction mechanisms will be described. |
| **Literature** | gängige einführende Werke zur Organischen Chemie. Z.B. „Organische Chemie“ von K.P.C.Vollhart & N.E.Schore, Wiley VCH |

| Course L0832: Organic Chemistry | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Nina Schützenmeister, Robert Meyer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The lecture covers basic concepts of organic chemistry. This includes simple carbon compounds, alkanes, alkenes, aromatic compounds, alcohols, phenols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, amides and amino acids. Further, fundamentals of reaction mechanisms will be described. This includes nucleophilic substitution, eliminations, additions and aromatic substitution. Also modern reaction mechanisms will be described.<br><br>Prior to each experiment, an oral colloquium takes place in small groups. In the colloquium are security aspects of the experiments are discussed, as well as the topics of the experiments. Solutions to previously provided questions are answered. In the colloquia the students acquire the skill to express scientific matters orally in a scientifically correct language and to describe theoretical basics.<br><br>The students write up a report for every experiment. They receive feedback to their level of scientific writing (citation methods, labeling of graphs, etc.), so that they can improve their competence in this field over the course of the practical course. |
| **Literature** | gängige einführende Werke zur Organischen Chemie. Z.B. „Organische Chemie“ von K.P.C.Vollhart & N.E.Schore, Wiley VCH |

| Course L3184: Organic Chemistry | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Nina Schützenmeister, Robert Meyer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | |

## Module M0851: Mathematics II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Mathematics II (L2976) | Lecture | 4 | 4 |
| Mathematics II (L2977) | Recitation Section (large) | 2 | 2 |
| Mathematics II (L2978) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Anusch Taraz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can name further concepts in analysis and linear algebra. They are able to explain them using appropriate examples.<br>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.<br>• They know proof strategies and can reproduce them. |
| *Skills* | • Students can model problems in analysis and linear algebra with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods.<br>• Students are able to discover and verify further logical connections between the concepts studied in the course.<br>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to work together in teams. They are capable to use mathematics as a common language.<br>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers. |
| *Autonomy* | • Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.<br>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems. |
| **Workload in Hours** | Independent Study Time 128, Study Time in Lecture 112 |
| **Credit points** | 8 |
| **Course achievement** | Compulsory: Yes; Bonus: 10 %; Form: Excercises; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| Course L2976: Mathematics II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Lecturer** | Prof. Anusch Taraz |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Analysis:<br>• power series and elementary functions<br>• interpolation<br>• integration (proper integrals, fundamental theorem, integration rules, improper integrals, parameter dependent integrals<br>• applications of integration (volume and surface of bodies of revolution, lines and arc length, line integrals<br>• numerical quadrature<br>• periodic functions<br>Linear Algebra:<br>• general vector spaces: subspaces, Euclidean vector spaces<br>• linear mappings: basis transformation, orthogonal projection, orthogonal matrices, householder matrices<br>• linear regression: normal equations, linear discrete approximation<br>• eigenvalues: diagonalising matrices, normal matrices, symmetric and Hermite matrices<br>• system of linear differential equations<br>• matrix factorizations: LR-decomposition, QR-decomposition, Schur decomposition, Jordan normal form, singular value decomposition |
| **Literature** | • T. Arens u.a. : Mathematik, Spektrum Akademischer Verlag, Heidelberg 2009<br>• W. Mackens, H. Voß: Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994<br>• W. Mackens, H. Voß: Aufgaben und Lösungen zur Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994<br>• G. Strang: Lineare Algebra, Springer-Verlag, 2003<br>• G. und S. Teschl: Mathematik für Informatiker, Band 1, Springer-Verlag, 2013 |

| Course L2977: Mathematics II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anusch Taraz |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L2978: Mathematics II | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anusch Taraz |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0671: Technical Thermodynamics I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Technical Thermodynamics I (L0437) | Lecture | 2 | 4 |
| Technical Thermodynamics I (L0439) | Recitation Section (large) | 1 | 1 |
| Technical Thermodynamics I (L0441) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Arne Speerforck |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Elementary knowledge in Mathematics and Mechanics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are familiar with the laws of Thermodynamics. They know the relation of the kinds of energy according to 1 $^{st}$ law of Thermodynamics and are aware about the limits of energy conversions according to 2$^{nd}$ law of Thermodynamics. They are able to distinguish between state variables and process variables and know the meaning of different state variables like temperature, enthalpy, entropy and also the meaning of exergy and anergy. They are able to draw the Carnot cycle in a Thermodynamics related diagram. They know the physical difference between an ideal and a real gas and are able to use the related equations of state. They know the meaning of a fundamental state of equation and know the basics of two phase Thermodynamics. |
| *Skills* | Students are able to calculate the internal energy, the enthalpy, the kinetic and the potential energy as well as work and heat for simple change of states and to use this calculations for the Carnot cycle. They are able to calculate state variables for an ideal and for a real gas from measured thermal state variables. |
| **Personal Competence** | |
| *Social Competence* | The students can discuss in small groups and work out a solution. You can answer comprehension questions about the content that are provided in the lecture with the ClickerOnline tool "TurningPoint" after discussions with other students. |
| *Autonomy* | Students can understand the problems posed in tasks physically. They are able to select the methods taught in the lecture and exercise to solve problems and apply them independently to different types of tasks. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Engineering Science: Specialisation Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>Engineering Science: Specialisation Advanced Materials: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory |

| Course L0437: Technical Thermodynamics I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Arne Speerforck |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction<br>2. Fundamental terms<br>3. Thermal Equilibrium and temperature<br>3.1 Thermal equation of state<br>4. First law<br>4.1 Heat and work<br>4.2 First law for closed systems<br>4.3 First law for open systems<br>4.4 Examples<br>5. Equations of state and changes of state<br>5.1 Changes of state<br>5.2 Cycle processes<br>6. Second law<br>6.1 Carnot process<br>6.2 Entropy<br>6.3 Examples<br>6.4 Exergy<br>7. Thermodynamic properties of pure fluids<br>7.1 Fundamental equations of Thermodynamics<br>7.2 Thermodynamic potentials<br>7.3 Calorific state variables for arbritary fluids<br>7.4 state equations (van der Waals u.a.) |
| **Literature** | • Schmitz, G.: Technische Thermodynamik, TuTech Verlag, Hamburg, 2009<br>• Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Auflage, Springer Verlag, Berlin 2012<br>• Potter, M.; Somerton, C.: Thermodynamics for Engineers, Mc GrawHill, 1993 |

| Course L0439: Technical Thermodynamics I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Arne Speerforck |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0441: Technical Thermodynamics I | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Arne Speerforck |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1803: Engineering Mechanics II (Elastostatics)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Engineering Mechanics II (Elastostatics) (L0493) | Lecture | 2 | 2 |
| Engineering Mechanics II (Elastostatics) (L1691) | Recitation Section (large) | 2 | 2 |
| Engineering Mechanics II (Elastostatics) (L0494) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Christian Cyron |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Engineering Mechanics I, Mathematics I (basic knowledge of rigid body mechanics such as balance of linear and angular momentum, basic knowledge of linear algebra like vector-matrix calculus, basic knowledge of analysis such as differential and integral calculus) |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Having accomplished this module, the students know and understand the basic concepts of continuum mechanics and elastostatics, in particular stress, strain, constitutive laws, stretching, bending, torsion, failure analysis, energy methods and stability of structures. |
| *Skills* | Having accomplished this module, the students are able to<br>- apply the fundamental concepts of mathematical and mechanical modeling and analysis to problems of their choice<br>- apply the basic methods of elastostatics to problems of engineering, in particular in the design of mechanical structures<br>- to educate themselves about more advanced aspects of elastostatics |
| **Personal Competence** | |
| *Social Competence* | Ability to communicate complex problems in elastostatics, to work out solution to these problems together with others, and to communicate these solutions. |
| *Autonomy* | Self-discipline and endurance in tackling independently complex challenges in elastostatics; ability to learn also very abstract knowledge. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| Course L0493: Engineering Mechanics II (Elastostatics) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Cyron |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The lecture Engineering Mechanics II introduces the fundamental concepts of stress and strain and explains how these can be used to characterize and compute elastic deformations of mechanical bodies under loading. The focus of the lecture lies on:<br>• basis of continuum mechanics: stress, strain, constitutive laws<br>• truss<br>• torsion bar<br>• beam theory: bending, moment of inertia of area, transverse shear<br>• energy methods: Maxwell-Betti reciprocal work theorem, Castigliano's second theorem, theorem of Menabrea<br>• strength of materials: maximum principle stress criterion, yield criteria according to Tresca and von Mises<br>• stability of mechanical structures: Euler buckling strut |
| **Literature** | • Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 1, Springer<br>• Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 2 Elastostatik, Springer |

| Course L1691: Engineering Mechanics II (Elastostatics) | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Cyron |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0494: Engineering Mechanics II (Elastostatics) | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Cyron |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1751: Practical module 2 (dual study program, Bachelor's degree)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical term 2 (dual study program, Bachelor's degree) (L2880) | | 0 | 6 |

| | |
|---|---|
| **Module Responsible** | Dr. Henning Haschke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Successful completion of practical module 1 as part of the dual Bachelor's course<br>• course A from the module on interlinking theory and practice as part of the dual Bachelor's course |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students ...<br>• ... describe their employer's organisational structure (company) and differentiate between associated regulations that relate to how tasks and competences are distributed, as well as how work processes are handled.<br>• ... understand the structure and objectives of the dual study programme and the increasing requirements throughout the course of study. |
| *Skills* | Dual students ...<br>• ... use equipment and resources professionally in accordance with the assigned work areas and tasks, and assess operational processes and procedures with regard to the intended work results/objectives.<br>• ... implement the university's application recommendations in relation to their current tasks. |
| **Personal Competence** | |
| *Social Competence* | Dual students ...<br>• ... have familiarised themselves with their new working environment (learning environment) and the associated tasks/processes/working relationships.<br>• ... know their central points of contact and colleagues, and are integrated into the designated tasks and work areas.<br>• ... coordinate work tasks with their professional supervisor and justify procedures and intended results.<br>• ... help shape the work in the assigned work area and offer their colleagues support to complete their work or ask for support based on their needs.<br>• ... work together with others in interdisciplinary work teams in a result-oriented manner. |
| *Autonomy* | Dual students ...<br>• ... structure their work and learning processes within the company independently in line with their responsibilities and authorisations, and coordinate them with their professional supervisor.<br>• ... complete work tasks/assignments independently and/or with the support of colleagues.<br>• ... coordinate the practical phase with any individual preparation required for the examination phase at TUHH.<br>• ... document and reflect on how their foundational subjects link with their work as an engineer. |
| **Workload in Hours** | Independent Study Time 180, Study Time in Lecture 0 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase. |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Computer Science: Core Qualification: Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Engineering Science: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| Course L2880: Practical term 2 (dual study program, Bachelor's degree) | |
|---|---|
| **Typ** | |
| **Hrs/wk** | 0 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 180, Study Time in Lecture 0 |
| **Lecturer** | Dr. Henning Haschke |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | **Company onboarding process**<br>• Assigning work areas (supervisor, colleagues)<br>• Assigning a contact person within the company (usually the HR department)<br>• Assigning a professional mentor in the work area (relating to practical application)<br>• Responsibilities and authorisations of the dual student within the company<br>• Supporting/working with colleagues<br>• Scheduling the relevant practical modules with work tasks<br>• Theory/practice transfer options<br>• Scheduling the examination phase/subsequent study semester<br>**Operational knowledge and skills**<br>• Company-specific: organisational structure, corporate strategy, business and work areas, work procedures and processes, operational levels<br>• Process and procedure options within the labour-market-relevant field of engineering<br>• Operational equipment and resources<br>• Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company<br>**Sharing/reflecting on learning**<br>• Creating an e-portfolio<br>• Relevance of foundational subjects when working as an engineer<br>• Comparing the learning and working processes of different learning environments with regard to their results and effects |
| **Literature** | • Studierendenhandbuch<br>• Betriebliche Dokumente<br>• Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer |

## Module M0608: Basics of Electrical Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Basics of Electrical Engineering (L0290) | Lecture | 3 | 4 |
| Basics of Electrical Engineering (L0292) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Thorsten Kern |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of mathematics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can to draw and explain circuit diagrams for electric and electronic circuits with a small number of components. They can describe the basic function of electric and electronic componentes and can present the corresponding equations. They can demonstrate the use of the standard methods for calculations. |
| *Skills* | Students are able to analyse electric and electronic circuits with few components and to calculate selected quantities in the circuits. They apply the ususal methods of the electrical engineering for this. |
| **Personal Competence** | |
| *Social Competence* | Students are enabled to collaborate in interdisciplinary teams with electrical engineering as a common language<br>With this, they are learning communication in a target-oriented communication style, are able to understand interfaces to neighboring engineering disciplines and learn about commonalities but also limits in the different directions of engineering. |
| *Autonomy* | Students are able independently to analyse electric and electronic circuits and to calculate selected quantities in the circuits. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>No / 20 % / Subject theoretical and practical work / Während des Semesters werden Hausarbeiten in Form von elektrischen Aufgaben vergeben, für die durch Simulation eine Lösung entwickelt und nachgewiesen werden muss. |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | 135 minutes |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory |

### Course L0290: Basics of Electrical Engineering

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Thorsten Kern |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | DC networks: Current, voltage, power, Kirchhoff's laws, equivalent sources, network analysis<br>AC: Characteristics, RMS, complexe representation, phasor diagrams, power<br>Three phase AC: Characterisitics, star-delta- connection, power, transformer<br>Elektronics: Principle, operating behaviour and application of electronic devises as diode, Zener-diode, thyristor, transistor operational amplifier |
| **Literature** | Alexander von Weiss, Manfred Krause: "Allgemeine Elektrotechnik"; Viweg-Verlag, Signatur der Bibliothek der TUHH: ETB 309<br>Ralf Kories, Heinz Schmitt - Walter: "Taschenbuch der Elektrotechnik"; Verlag Harri Deutsch; Signatur der Bibliothek der TUHH: ETB 122<br>"Grundlagen der Elektrotechnik" - andere Autoren |

| Course L0292: Basics of Electrical Engineering | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Kern, Weitere Mitarbeiter |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Excercises to the analysis of circuits and the calculation of electrical quantities th the topics:<br><br>DC networks: Current, voltage, power, Kirchhoff's laws, equivalent sources,<br>network analysis<br><br>AC: Characteristics, RMS, complexe representation, phasor diagrams, power<br>Three phase AC: Characterisitics, star-delta- connection, power, transformer<br><br>Elektronics: Principle, operating behaviour and application of electronic devises as diode, Zener-diode, thyristor, transistor operational amplifier |
| **Literature** | Alexander von Weiss, Manfred Krause: "Allgemeine Elektrotechnik"; Viweg-Verlag, Signatur der Bibliothek der TUHH: ETB 309<br>Ralf Kories, Heinz Schmitt - Walter: "Taschenbuch der Elektrotechnik"; Verlag Harri Deutsch; Signatur der Bibliothek der TUHH: ETB 122<br>"Grundlagen der Elektrotechnik" - andere Autoren |

## Module M0853: Mathematics III

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Analysis III (L1028) | Lecture | 2 | 2 |
| Analysis III (L1029) | Recitation Section (small) | 1 | 1 |
| Analysis III (L1030) | Recitation Section (large) | 1 | 1 |
| Differential Equations 1 (Ordinary Differential Equations) (L1031) | Lecture | 2 | 2 |
| Differential Equations 1 (Ordinary Differential Equations) (L1032) | Recitation Section (small) | 1 | 1 |
| Differential Equations 1 (Ordinary Differential Equations) (L1033) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Marko Lindner |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I + II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can name the basic concepts in the area of analysis and differential equations. They are able to explain them using appropriate examples.<br>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.<br>• They know proof strategies and can reproduce them. |
| *Skills* | • Students can model problems in the area of analysis and differential equations with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods.<br>• Students are able to discover and verify further logical connections between the concepts studied in the course.<br>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to work together in teams. They are capable to use mathematics as a common language.<br>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers. |
| *Autonomy* | • Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.<br>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems. |
| **Workload in Hours** | Independent Study Time 128, Study Time in Lecture 112 |
| **Credit points** | 8 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min (Analysis III) + 60 min (Differential Equations 1) |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Logistics and Mobility: Specialisation Information Technology: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Compulsory |

| Course L1028: Analysis III | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Main features of differential and integrational calculus of several variables<br>• Differential calculus for several variables<br>• Mean value theorems and Taylor's theorem<br>• Maximum and minimum values<br>• Implicit functions<br>• Minimization under equality constraints<br>• Newton's method for multiple variables<br>• Fourier series<br>• Double integrals over general regions<br>• Line and surface integrals<br>• Theorems of Gauß and Stokes |
| **Literature** | • http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html |

| Course L1029: Analysis III | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1030: Analysis III | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1031: Differential Equations 1 (Ordinary Differential Equations) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Main features of the theory and numerical treatment of ordinary differential equations<br>• Introduction and elementary methods<br>• Exsitence and uniqueness of initial value problems<br>• Linear differential equations<br>• Stability and qualitative behaviour of the solution<br>• Boundary value problems and basic concepts of calculus of variations<br>• Eigenvalue problems<br>• Numerical methods for the integration of initial and boundary value problems<br>• Classification of partial differential equations |
| **Literature** | • http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html |

| Course L1032: Differential Equations 1 (Ordinary Differential Equations) | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1033: Differential Equations 1 (Ordinary Differential Equations) | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0688: Technical Thermodynamics II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Technical Thermodynamics II (L0449) | Lecture | 2 | 4 |
| Technical Thermodynamics II (L0450) | Recitation Section (large) | 1 | 1 |
| Technical Thermodynamics II (L0451) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Arne Speerforck |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Elementary knowledge in Mathematics, Mechanics and Technical Thermodynamics I |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are familiar with different cycle processes like Joule, Otto, Diesel, Stirling, Seiliger and Clausius-Rankine. They are able to derive energetic and exergetic efficiencies and know the influence different factors. They know the difference between anti clockwise and clockwise cycles (heat-power cycle, cooling cycle). They have increased knowledge of steam cycles and are able to draw the different cycles in Thermodynamics related diagrams. They know the laws of gas mixtures, especially of humid air processes and are able to perform simple combustion calculations. They are provided with basic knowledge in gas dynamics and know the definition of the speed of sound and know about a Laval nozzle. |
| *Skills* | Students are able to use thermodynamic laws for the design of technical processes. Especially they are able to formulate energy, exergy- and entropy balances and by this to optimise technical processes. They are able to perform simple safety calculations in regard to an outflowing gas from a tank. They are able to transform a verbal formulated message into an abstract formal procedure. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss in small groups and develop an approach. You can answer comprehension questions about the content that are provided in the lecture with the ClickerOnline tool "TurningPoint" after discussions with other students. |
| *Autonomy* | Students can physically understand and explain the complex problems (cycle processes, air conditioning processes, combustion processes) set in tasks. They are able to select the methods taught in the lecture and exercise to solve complex problems and apply them independently to different types of tasks. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0449: Technical Thermodynamics II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Arne Speerforck |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 8. Cycle processes<br>7. Gas - vapor - mixtures<br>10. Open sytems with constant flow rates<br>11. Combustion processes<br>12. Special fields of Thermodynamics |
| **Literature** | • Schmitz, G.: Technische Thermodynamik, TuTech Verlag, Hamburg, 2009<br>• Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Auflage, Springer Verlag, Berlin 2012<br>• Potter, M.; Somerton, C.: Thermodynamics for Engineers, Mc GrawHill, 1993 |

| Course L0450: Technical Thermodynamics II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Arne Speerforck |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0451: Technical Thermodynamics II | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Arne Speerforck |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1497: Measurement Technology for Chemical and Bioprocess Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical Course Measurement Technology (L2270) | Practical Course | 2 | 2 |
| Measurement Technology (L2268) | Lecture | 2 | 2 |
| Physical Fundamentals of Measurement Technology (L2269) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Alexander Penn |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Technical interest, logical skills, integral- and differential calculus, basic physical concepts such as temperature, mass, velocity, etc.. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Physical basics: kinematics and dynamics (theory of motion), rotation of rigid bodies, energy and momentum, electricity, magnetism, basics of hydrodynamics, temperature and heat, ideal gas.<br><br>Metrology: SI units, measurement and measurement uncertainty, basics of sensor technology, physical principles, temperature measurement, pressure measurement, level measurement, flow measurement. Usage of Matlab scripts.<br><br>Practical course: Pressure drop in piping, calorimetry, image data acquisition, flow measurement, concentration measurement and mass transfer, capacitive measurements of solid concentrations, spectroscopy, error calculation, chromatography |
| *Skills* | Literature research, categorisation of thematical topics, analysis of an experimental test stand, preparation of test protocol, first programming with Matlab, use of relevant laboratory measurement technology, preparation of a test protocol, execution of calculations. |
| **Personal Competence** | |
| *Social Competence* | Arrangement and division of work in practical training and learning groups, assessment of own level of knowledge, work on the experimental stand in groups, consultation with persons responsible for teaching, presentation of the preparation of the experiment, tolerance of frustration |
| *Autonomy* | Time management of the workload, independent development of the thematic basics, personal responsibility for the provision of protective equipment and work clothing, practice of presentation in front of a group, active participation in the lectures, formulation of enquiries/detailed questions by using clicker. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |

**Course achievement**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| Yes | None | Attestation | Testate Messtechnikpraktikum |
| No | 20 % | Excercises | Popup-Quizzes währen der Vorlesung |

| | |
|---|---|
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

### Course L2270: Practical Course Measurement Technology

| | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Alexander Penn |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | In the Practical Course in Measurement Technology the theory from the lectures "Physical Fundamentals of Measurement Technology" and "Measurement Technology" will be applied in practice. In small groups students learn how to handle different measurement techniques from industry and research. During the practical course, a wide range of different measurement methods will be taught, including the use of HLPC columns for qualitative mass analysis, the determination of mass transfer coefficients using optical oxygen sensors or the evaluation of image data to obtain process parameters. The practical course also teaches how measurement data are statistically evaluated and experiments are correctly documented. |
| **Literature** | Hug, H.: Instrumentelle Analytik. Theorie und Praxis. Verlag Europa-Lehrmittel, Haan-Gruiten, 2015.<br><br>Kamke, W.: Der Umgang mit experimentellen Daten, insbesondere Fehleranalyse, im physikalischen Anfänger-Praktikum. Eine elementare Einführung. W. Kamke, Kirchzarten [Keltenring 197], 2010.<br><br>Strohrmann, G.: Messtechnik im Chemiebetrieb. Einführung in das Messen verfahrenstechnischer Größen. Oldenbourg, München, 2004. |

| Course L2268: Measurement Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Alexander Penn |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Basic introduction to measurement technology for process engineers. Includes error calculation, measurement units, calibration, measurement data analysis, measurement techniques and sensors. Particular attention is paid to the measurement of temperature, pressure, flow and level. The lecture provides insights into the latest developments in sensor technology in measurement technology and process engineering. |
| **Literature** | Fraden, Jacob (2016): Handbook of Modern Sensors. Physics, Designs, and Applications. 5th ed. 2016. Cham, New York: Springer. Online verfügbar unter http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&AN=1081958.<br><br>Hering, Ekbert; Schönfelder, Gert (2018): Sensoren in Wissenschaft und Technik. Funktionsweise und Einsatzgebiete. 2. Aufl. 2018. Online verfügbar unter http://dx.doi.org/10.1007/978-3-658-12562-2.<br><br>Strohrmann, Günther (2004): Messtechnik im Chemiebetrieb. Einführung in das Messen verfahrenstechnischer Größen. 10., durchges. Aufl. München: Oldenbourg.<br><br>Tränkler, Hans-Rolf; Reindl, Leonhard M. (2014): Sensortechnik. Handbuch für Praxis und Wissenschaft. 2., völlig neu bearb. Aufl. Berlin: Springer Vieweg (VDI-Buch). Online verfügbar unter http://dx.doi.org/10.1007/978-3-642-29942-1.<br><br>Webster, John G.; Eren, Halit B. (2014): Measurement, Instrumentation, and Sensors Handbook, Second Edition. Electromagnetic, Optical, Radiation, Chemical, and Biomedical Measurement. 2nd ed. Hoboken: Taylor and Francis. Online verfügbar unter http://gbv.eblib.com/patron/FullRecord.aspx?p=1407945. |

| Course L2269: Physical Fundamentals of Measurement Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Schroer |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Classical mechanics - kinematics, dynamics, energy, momentum and conservation laws, rigid bodies, translation and rotation, angular momentum.<br>Mechanics of gases and fluids - hydrostatics and hydrodynamics<br>Thermodynamics - temperature, heat, heat transport, ideal gas, changes of state, cyclic processes, laws of thermodynamics<br>Electricity - electrostatics, electrical conduction, magnetism, Lorentz force, Maxwell's equations (integral form) |
| **Literature** | Paul A. Tipler, Gene Mosca: Physik für Wissenschaftler und Ingenieure, Spektrum Verlag<br><br>D. Meschede (Hrsg.): Gerthsen Physik, Springer-Verlag<br><br>Jay Orear: Physik, Hanser Verlag<br><br>D. Halliday, R. Resnick, J. Walker: Physik, Wiley VCH |

## Module M1712: Green Technologies II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical Exercise Environmental Technology (L1387) | Practical Course | 1 | 1 |
| Pollutant analysis (L2996) | Lecture | 2 | 3 |
| Environmental Technologie (L0326) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Dr. Marvin Scherzinger |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of inorganic/organic chemistry and biology. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | With the completion of this modul the students obtain profound knowledge of environmental technology. They are able to describe the behaviour of chemicals in the environment. Students can give an overview of scientific disciplines involved. They can explain terms and allocate them to related methods.<br><br>Additional students acquire in-depth knowledge of important cause-effect chains of potential environmental problems which might occur from production processes, projects or construction measures. They have knowledge about the methodological diversity and are competent in dealing with different methods and instruments to assess environmental impacts. Besides the students are able to estimate the complexity of these environmental processes as well as uncertainties and difficulties with their measurement. |
| *Skills* | Students are able to propose appropriate management and mitigation measures for environmental problems. They are able to determine geochemical parameters and to assess the potential of pollutants to migrate and transform. The students are able to work out well founded opinions on how Environmental Technology contributes to sustainable development, and they can present and defend these opinons in front of and against the group.<br><br>The students are able to select a suitable method for the respective case from the variety of assessment methods. Thereby they can develop suitable solutions for managing and mitigating environmental problems in a business context. They are able to carry out Life Cycle Impact Assessments independently and can apply the software programs OpenLCA and the database EcoInvent. After finishing the course the students have the competence to critically judge research results or other publications on environmental impacts. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss the various technical and scientific tasks, both subject-specific and multidisciplinary. They are able to develop different approaches to the task as a group as well as to discuss their theoretical or practical implementation.<br><br>Due to the selected lecture topics, the students receive insights into the multi-layered issues of the environment protection and the concept of sustainability. Their sensitivity and consciousness towards these subjects are raised and which helps to raise their awareness of their future social responsibilities in their role as engineers. |
| *Autonomy* | The students learn to research, process and present a scientific topic independently. They are able to carry out independent scientific work. They can solve an environmental problem in a business context and are able to judge results of other publications. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** None; **Form** Subject theoretical and practical work; **Description** Praktikum "Umwelttechnik" |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory |

| Course L1387: Practical Exercise Environmental Technology | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The practical course Environmental Engineering currently consists of 5 experiments, which deal with the different focal points of environmental engineering in the areas of air, water, soil, energy and noise. The following experiments are carried out for this purpose:<br>biological degradation of artificial materials,<br>fine dust measurement in the air,<br>water analysis,<br>noise emission measurement,<br>photovoltaic energy<br><br>Within the lab course students discuss the various technical and scientific tasks, both subject-specific and multidisciplinary. They discuss different approaches to the task as well as it's theoretical or practical implementation. |
| **Literature** | Folien der Einführungsveranstaltung |

| Course L2996: Pollutant analysis | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Marvin Scherzinger |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | In this course, modern analytical methods are presented that are used for the quantification of pollutants in the environmental compartments soil, water and air. In doing so, the students deepen their theoretical knowledge with regard to working with standardized methods and learn to make statements about the quality of test results. |
| **Literature** | Vorlesungsfolien |

| Course L0326: Environmental Technologie | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Martin Kaltschmitt, Dr. Marvin Scherzinger |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 1. Introductory seminar on environmental science:<br>2. Environmental impact and adverse effects<br>3. Wastewater technology<br>4. Air pollution control<br>5. Noise protection<br>6. Waste and recycling management<br>7. Soil and ground water protection<br>8. Renewable energies<br>9. Resource conservation and energy efficiency |
| **Literature** | Förster, U.: Umweltschutztechnik; 2012; Springer Berlin (Verlag) 8., Aufl. 2012; 978-3-642-22972-5 (ISBN) |

## Module M1752: Practical module 3 (dual study program, Bachelor's degree)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical term 3 (dual study program, Bachelor's degree) (L2881) | | 0 | 6 |

| | |
|---|---|
| **Module Responsible** | Dr. Henning Haschke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Successful completion of practical module 2 as part of the dual Bachelor’s course<br>• course B from the module on interlinking theory and practice as part of the dual Bachelor’s course |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students ...<br>• ... understand the company’s strategic orientation, as well as the functions and organisation of central departments with their decision-making structures, network relationships.<br>• ... understand the requirements of the engineering profession and correctly estimate the resulting responsibility.<br>• ... combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity. |
| *Skills* | Dual students ...<br>• ... apply technical theoretical knowledge to current problems in their own area of work, and evaluate work processes and results.<br>• ... use technology, equipment and resources in accordance with the assigned work areas and tasks, and assess operational processes and procedures with regard to the intended work results/objectives.<br>• ... implement the university’s application recommendations in relation to their current tasks. |
| **Personal Competence** | |
| *Social Competence* | Dual students ...<br>• ... plan work processes cooperatively, including across work areas.<br>• ... communicate professionally with operational stakeholders and present complex issues in a structured, targeted and convincing manner. |
| *Autonomy* | Dual students ...<br>• ... assume responsibility for work assignments and areas.<br>• ... document and reflect on the relevance of subject modules and specialisations for work as an engineer, as well as the implementation of the university’s application recommendations and the associated challenges of a positive transfer of knowledge between theory and practice. |
| **Workload in Hours** | Independent Study Time 180, Study Time in Lecture 0 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase. |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Computer Science: Core Qualification: Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Engineering Science: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| Course L2881: Practical term 3 (dual study program, Bachelor's degree) | |
|---|---|
| **Typ** | |
| **Hrs/wk** | 0 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 180, Study Time in Lecture 0 |
| **Lecturer** | Dr. Henning Haschke |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | **Company onboarding process**<br>• Assigning work area(s)<br>• Extending responsibilities and authorisations of the dual student within the company<br>• Independent work tasks and areas<br>• Participating in project teams<br>• Scheduling the relevant practical modules with work tasks<br>• Theory/practice transfer options<br>• Scheduling the examination phase/subsequent study semester<br>**Operational knowledge and skills**<br>• Company-specific: strategic direction, organisation of central business and work areas, departments, decision-making structures, network relationships and internal communication<br>• Linking facts, principles and theories with practical knowledge<br>• Process and procedure options within the labour-market-relevant field of engineering<br>• Operational technology, equipment and resources<br>• Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company<br>**Sharing/reflecting on learning**<br>• E-portfolio<br>• Relevance of subject modules and specialisations when working as an engineer<br>• University application recommendations for transferring knowledge between theory and practice |
| **Literature** | • Studierendenhandbuch<br>• Betriebliche Dokumente<br>• Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer |

## Module M0536: Fundamentals of Fluid Mechanics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Fluid Mechanics (L0091) | Lecture | 2 | 2 |
| Fundamentals on Fluid Mechanics (L2933) | Recitation Section (small) | 2 | 2 |
| Fluid Mechanics for Process Engineering (L0092) | Recitation Section (large) | 2 | 2 |

**Module Responsible**
Prof. Michael Schlüter

**Admission Requirements**
None

**Recommended Previous Knowledge**

- Mathematics I+II+III
- Technical Mechanics I+II
- Technical Thermodynamics I+II
- Working with force balances
- Simplification and solving of partial differential equations
- Integration

**Educational Objectives**
After taking part successfully, students have reached the following learning results

**Professional Competence**

*Knowledge*
Students are able to:

- explain the difference between different types of flow
- give an overview for different applications of the Reynolds Transport-Theorem in process engineering
- explain simplifications of the Continuity- and Navier-Stokes-Equation by using physical boundary conditions

*Skills*
The students are able to

- describe and model incompressible flows mathematically
- reduce the governing equations of fluid mechanics by simplifications to archive quantitative solutions e.g. by integration
- notice the dependency between theory and technical applications
- use the learned basics for fluid dynamical applications in fields of process engineering

**Personal Competence**

*Social Competence*
The students

- are capable to gather information from subject related, professional publications and relate that information to the context of the lecture and
- able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises)
- are able to work out solutions for exercises by themselves, to discuss the solutions orally and to present the results.

*Autonomy*
The students are able to

- search further literature for each topic and to expand their knowledge with this literature,
- work on their exercises by their own and to evaluate their actual knowledge with the feedback.

**Workload in Hours**
Independent Study Time 96, Study Time in Lecture 84

**Credit points**
6

**Course achievement**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| No | 5 % | Midterm | |

**Examination**
Written exam

**Examination duration and scale**
3 hours

**Assignment for the Following Curricula**
General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory
General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory
Bioprocess Engineering: Core Qualification: Compulsory
Chemical and Bioprocess Engineering: Core Qualification: Compulsory
Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory
Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory
Integrated Building Technology: Core Qualification: Compulsory
Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory
Technomathematics: Specialisation III. Engineering Science: Elective Compulsory
Process Engineering: Core Qualification: Compulsory
Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory

| Course L0091: Fundamentals of Fluid Mechanics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • fluid properties<br>• hydrostatic<br>• overall balances - theory of streamline<br>• overall balances- conservation equations<br>• differential balances - Navier Stokes equations<br>• irrotational flows - Potenzialströmungen<br>• flow around bodies - theory of physical similarity<br>• turbulent flows<br>• compressible flows |
| **Literature** | 1. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.<br>2. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.<br>3. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994<br>4. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006<br>5. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008<br>6. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007<br>7. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2009<br>8. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007<br>9. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008<br>10. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006<br>11. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.<br>12. White, F.: Fluid Mechanics, Mcgraw-Hill, ISBN-10: 0071311211, ISBN-13: 978-0071311212, 2011 |

| Course L2933: Fundamentals on Fluid Mechanics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | In the group exercise, the contents of the lecture are taken up and deepened by means of exercises. The exercise tasks correspond in quality and scope to the tasks of the written exam. Topics: Reynolds transport-theorem, pipe flow, free jet, angular momentum, Navier-Stokes equations, potential theory, mock exam, pipe hydraulics, pump design. |
| **Literature** | Heinz Herwig: Strömungsmechanik, Eine Einführung in die Physik und die mathematische Modellierung von Strömungen, Springer Verlag, Berlin, 978-3-540-32441-6 (ISBN)<br><br>Herbert Oertel, Martin Böhle, Thomas Reviol: Strömungsmechanik für Ingenieure und Naturwissenschaftler, Springer Verlag, Berlin, ISBN: 978-3-658-07786-0<br><br>Joseph Spurk, Nuri Aksel: Strömungslehre, Einführung in die Theorie der Strömungen, Springer Verlag, Berlin, ISBN: 978-3-642-13143-1. |

| Course L0092: Fluid Mechanics for Process Engineering | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | In the exercise-lecture the topics from the main lecture are discussed intensively and transferred into application. For that, the students receive example tasks for download. The students solve these problems based on the lecture material either independently or in small groups. The solution is discussed with the students under scientific supervision and parts of the solutions are presented on the chalk board. At the end of each exercise-lecture, the correct solution is presented on the chalk board. Parallel to the exercise-lecture tutorials are held where the student solve exam questions under a set time-frame in small groups and discuss the solutions afterwards. |
| **Literature** | 1. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.<br>2. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.<br>3. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994<br>4. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006<br>5. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008<br>6. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007<br>7. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2009<br>8. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007<br>9. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008<br>10. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006<br>11. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.<br>12. White, F.: Fluid Mechanics, Mcgraw-Hill, ISBN-10: 0071311211, ISBN-13: 978-0071311212, 2011 |

## Module M0686: Sanitary Engineering I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Wastewater Disposal (L0276) | Lecture | 2 | 2 |
| Wastewater Disposal (L0278) | Recitation Section (large) | 1 | 1 |
| Drinking Water Supply (L0306) | Lecture | 2 | 1 |
| Drinking Water Supply (L0308) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf Otterpohl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Basic knowledge on Chemistry and Biology<br>• Hydraulics of pipe systems and open channels<br>• Basic knowledge on water management: water quantity and water quality<br>• Basic knowledge on Environmental Legislation: Federal Water Act |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can examplify their expert knowledge on urban water infrastructures. They can present the derivation and detailed explanation of important standards for the design of drinking water supply and wastewater disposal systems in Germany and they are capable of reproducing the relevant empiricals assumptions and scientific simplifcations. The students are able to present and discuss sanitary engineering processes and the technologies used for drinking and wastewater treatment. They can also assess existing problems in the field of sanitary engineering by considering legal, risk and saftey aspects. Furthermore, they know how to draft the features and effectiveness of important technologies of the future such as high- and low-pressure membrane filtration systems and techniques for the removal of trace pollutants. |
| *Skills* | The students are able to apply the relevant standards and guidelines for the design and operation of urban water infrastructures independently. Their expertise comprises expert skills to design drinking water supply and urban drainage systems as well as the associated treatment facilities. Besides the acquirement of technical skills the students are able to address and solve biochemical problems in the filed of drinking water and wastewater treatment. The students are also able to develop ideas of their own to improve the existing water related infrastructures, systems and concepts. |
| **Personal Competence** | |
| *Social Competence* | Social skills are not targeted in this module. |
| *Autonomy* | Students are able to form concepts on their own to optimize urban water infrastructure processes. Therefore they can acquire appropriate knowledge when being given some clues or information with regard to the approach to problems (preparation and follow-up of the exercises). |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory |

| Course L0276: Wastewater Disposal | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | This lecture focusses on urban drainage and wastewater treatment.<br><br>Urban Drainage<br><br>• Design of urban drainage systems (combined and separate sewer systems)<br>• Special structures<br>• Rainwater management<br><br>Wastewater treatement<br><br>• Mechanical treatment (Screens, Grit chamber, Preliminary Sedimentation, Secondary Settlement Tanks, Membrane Filtration)<br>• Biological Treatment (aerobic, anaerobic, anoxic)<br>• Special Wastewater Treatment Processes (Ozonation, Adsorption) |
| **Literature** | Die hier aufgeführte Literatur ist in der Bibliothek der TUHH verfügbar.<br><br>The literature listed below is available in the library of the TUHH.<br><br>• Taschenbuch der Stadtentwässerung : mit 10 Tafeln und 67 Tabellen, Imhoff, K., & . (2009). (31., verbesserte Aufl.). München: Oldenbourg Industrieverl.<br>• Abwasser : Technik und Kontrolle. Neitzel, Volkmar, and. . Weinheim [u.a.]: Wiley-VCH, 1998.<br>• Kommunale Kläranlagen : Bemessung, Erweiterung, Optimierung, Betrieb und Kosten, (2009). Günthert, F. Wolfgang: (3., völlig neu bearb. Aufl.). Renningen: expert-Verl.<br>• Water and wastewater technology Hammer, M. J. 1., & . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International.<br>• Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill.<br>• Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ. |

| Course L0278: Wastewater Disposal | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0306: Drinking Water Supply | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Dr. Klaus Johannsen, Prof. Mathias Ernst |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The lecture on drinking water supply provides students with a basic understanding of the entire water supply system, encompassing water catchment, water treatment including pump systems, water storage, and the distribution system that carries water to the consumer.<br><br>Initially, basics in hydraulics and pump systems are presented (system curve and pump curve). Students learn how the duty point of the pump is determined. Students learn about different water resources and will be able to design groundwater wells. Students learn how to determine water demand and derive planning values for designing the different elements of a water supply system (e.g. firefighting requirements). The functions of reservoirs, their design and arrangement in the water supply system are explained. Students will be able to design simple water distribution systems.<br><br>A further part of the lecture deals with the processes involved in drinking water supply. This includes a presentation of the essential mechanisms and layout parameters for sedimentation, filtration, coagulation, membrane treatment, adsorption, water softening, gas exchange, ion exchange and disinfection. The basics of process treatment technology will be built on with parallel analysis of the impacts on chemical and physical water quality parameters. |
| **Literature** | Gujer, Willi (2007): Siedlungswasserwirtschaft. 3., bearb. Aufl., Springer-Verlag.<br><br>Karger, R., Cord-Landwehr, K., Hoffmann, F. (2005): Wasserversorgung. 12., vollst. überarb. Aufl., Teubner Verlag<br><br>Rautenberg, J. et al. (2014): Mutschmann/Stimmelmayr Taschenbuch der Wasserversorgung. 16. Aufl., Springer-Vieweg Verlag.<br><br>DVGW Lehr- und Handbuch Wasserversorgung: Wasseraufbereitung - Grundlagen und Verfahren, m. CD-ROM: Band 6 (2003). |

| Course L0308: Drinking Water Supply | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Dr. Klaus Johannsen, Prof. Mathias Ernst |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1714: Conventional Energy Systems and Energy Industry

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Power Industry (L0316) | Lecture | 1 | 1 |
| Energy markets and energy trading (L2744) | Lecture | 2 | 2 |
| Fossil Energy Systems (L2745) | Lecture | 2 | 2 |
| Fuels I (L3142) | Lecture | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Upon completion of this module, students will be able to provide an overview of characteristics of energy systems. They can explain the issues that arise. Furthermore, they are able to explain knowledge of energy production, energy distribution and energy trade in this context, taking into account contexts bordering on other disciplines. The students can explain this knowledge, which is applicable to almost all energy systems, in particular detail for conventional energy systems and take a critical stance on them. Furthermore, they can explain the environmental impact of using conventional energy systems. They also have an overview of reserves and resources as well as global and national market volumes. This also includes the legal framework, which should especially take into account the mitigation of climate change. |
| *Skills* | Students are able to apply methodologies for determining energy demand or energy supply to different types of energy systems. Furthermore, they can evaluate energy systems technically, ecologically and economically as well as systemically and are also able to design them under certain given conditions. They are able to select the regulations necessary for this in a subject-specific manner, especially by means of non-standard solutions to a problem.<br><br>Students are able to orally explain issues from the subject area and approaches to dealing with them and to classify them in the respective context. |
| **Personal Competence** | |
| *Social Competence* | The students are able to analyze suitable technical alternatives and to assess them with technical, economical and ecological criteria under sustainability aspects. |
| *Autonomy* | Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory |

### Course L0316: Power Industry

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Andreas Wiese |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Electrical energy in the energy system<br>• Demand and use of electrical energy (households, industry, "new" buyers (including e-mobility))<br>• Electricity generation<br>  ◦ electricity generation technologies using fossil fuels and their characteristics<br>  ◦ combined heat and power technologies and their production characteristics<br>  ◦ electricity generation from renewable energy technologies and their characteristics<br>• Power distribution<br>  ◦ "classic" distribution of electrical energy<br>  ◦ challenges of fluctuating electricity generation by distributed systems (electricity market, electricity stock exchange, emissions trading)<br>• District heating industry<br>• Legal and administrative aspects<br>  ◦ Energy Act<br>  ◦ support instruments for renewable energy<br>  ◦ CHP Act<br>• Cost and efficiency calculation |
| **Literature** | Folien der Vorlesung |

| Course L2744: Energy markets and energy trading | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Christian Wulf |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | This lecture addresses the mechanisms by which price formation works in global and national energy markets. For this purpose, the global price formation mechanism for crude oil and for natural gas and coal is explained. The national energy markets (e.g. power exchange, gas markets) are also discussed. The legal framework, which is ultimately decisive for market price formation, is always addressed. In this context, the various instruments with which the energy markets are to be influenced in such a way that climate protection already takes effect with market-based measures are also discussed. The expected future development/change of the energy markets against the background of the increasing use of renewable energies will also be addressed. |
| **Literature** | |

| Course L2745: Fossil Energy Systems | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Martin Kaltschmitt |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The aim of this lecture is to present and discuss the different fossil energy systems in their entirety. This includes the petroleum, natural gas, hard coal, lignite and nuclear energy systems. In each case, the formation processes, the exploration technologies, the exploration processes, the extraction technologies, the further processing processes and the corresponding utilization are presented. In addition, the respective markets and their development, the existing reserves and resources, and the environmental effects associated with extraction and utilization are discussed. A total system approach is pursued, which includes a presentation of the entire energy system including the given interdependencies and (geo)political dependencies. The current changes in these energy systems for Germany and internationally, and those that are expected in the coming years, are also discussed. In addition, the respective reserve and resource availability is illuminated. |
| **Literature** | Vorlesungsunterlagen |

| Course L3142: Fuels I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Karsten Wilbrand |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Regulatory requirements (including desulfurization)<br>• Overview of today's fossil fuels<br>o Gasoline,<br>o diesel,<br>o natural gas (GtL, CNG, LNG),<br>o kerosene,<br>o marine fuels<br>o Other fuels<br>• Markets and market developments<br>• CO2 analyses of the various options per application area<br>• Global megatrends and future challenges<br>• Developments in vehicle and drive technologies<br>• Energy scenarios up to 2050 and significance for the mobility sector |
| **Literature** | Eigene Unterlagen, Veröffentlichungen, Fachliteratur<br>Own documents, publications, technical literature |

## Module M1715: Renewable Energies

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fuels II (L3143) | Lecture | 1 | 1 |
| Renewable Energies I (L2740) | Lecture | 2 | 2 |
| Renewable Energies I (L2742) | Recitation Section (large) | 1 | 1 |
| Renewable Energies II (L2741) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Upon completion of this module, students will be able to provide an overview of characteristics of renewable energy systems. They will be able to explain the issues that arise in these systems. Furthermore, they are able to explain knowledge of energy supply, energy distribution and energy trading in this context, taking into account contexts bordering on specific disciplines. The students can explain this knowledge in detail for such energy systems and take a critical stand on it. Furthermore, they can explain the environmental impact of using renewable energy systems and have an overview of the economic classification of the respective options. |
| *Skills* | Students are able to apply methodologies for determining energy demand or energy supply to different types of renewable energy systems. Furthermore, they can evaluate such energy systems technically, ecologically and economically as well as systemically and also design them under certain given conditions. They are able to select the regulations necessary for this in a subject-specific manner, especially by means of non-standard solutions to a problem.<br><br>Students are able to orally explain issues from the subject area and approaches to dealing with them and to classify them in the respective context. |
| **Personal Competence** | |
| *Social Competence* | Students are able to investigate suitable technical alternatives and ultimately evaluate them based on technical, economic and ecological criteria - and thus from a sustainability perspective. |
| *Autonomy* | Students will be able to independently access sources about the field, acquire knowledge and transform it to address new issues. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory<br>Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering, Focus Chemical Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L3143: Fuels II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Karsten Wilbrand |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Regulatory requirements of "alternative" fuels (e.g. RED)<br>• Overview of today's alternative fuels<br>o Biodiesel / HEFA<br>o Bioethanol<br>o Biomethane<br>o Other fuels<br>• Overview of future alternative fuels<br>o 2nd generation biofuels<br>o Hydrogen and hydrogen derivatives<br>o Electricity-based fuels<br>o Other fuels<br>• Electromobility<br>o with battery<br>o with hydrogen fuel cell<br>• Markets and market developments<br>• CO2 analyses of the various options per application area<br>• Global megatrends and future challenges<br>• Developments in vehicle and drive technologies<br>• Energy scenarios up to 2050 and significance for the mobility sector |
| **Literature** | Eigene Unterlagen, Veröffentlichungen, Fachliteratur<br>Literature: Own documents, publications, technical literature |

| Course L2740: Renewable Energies I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Martin Kaltschmitt |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | This module includes a presentation of the renewable energy supply and a discussion of the respective technologies for providing the desired final or useful energy. Specifically, this includes the options for solar energy use for heat and power generation (i.e., passive solar energy use, solar collectors for low-temperature heat provision, solar thermal power generation, photovoltaic power generation), wind energy use for power generation (i.e. onshore and offshore wind power use), hydroelectric power use for electricity generation (i.e., run-of-river and storage hydroelectric power), ocean energy use for electricity generation (including tidal power plants), and geothermal energy use for heat and electricity generation (i.e., near-surface use by means of heat pumps, deep geothermal energy use for heat and/or electricity generation). |
| **Literature** | Kaltschmitt, M.; Streicher, W.; Wiese, A. (Hrsg.): Erneuerbare Energien - Systemtechnik, Wirtschaftlichkeit, Umweltaspekte; Springer, Berlin, Heidelberg, 2020, 6. Auflage |

| Course L2742: Renewable Energies I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Martin Kaltschmitt |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Students work on different tasks in the field of renewable energies. They present their solutions in the exercise lesson and discuss it with other students and the lecturer.<br><br>Possible tasks in the field of renewable energies are:<br><br>• Solar thermal heat<br>• Concentrating solare power<br>• Photovoltaic<br>• Windenergie<br>• Hydropower<br>• Heat pump<br><br>Deep geothermal energy |
| **Literature** | Kaltschmitt, M.; Streicher, W.; Wiese, A. (Hrsg.): Erneuerbare Energien - Systemtechnik, Wirtschaftlichkeit, Umweltaspekte; Springer, Berlin, Heidelberg, 2020, 6. Auflage |

| Course L2741: Renewable Energies II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Martin Kaltschmitt |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | This lecture covers all options for energy supply from biomass; this includes the supply of heat, electricity and fuels. The biomass resource and its origin will be discussed first. Afterwards the biomass supply is addressed, which bridges the gap between biomass generation and utilization. Subsequently, the different conversion options are discussed. Only those options are presented in depth that have a corresponding significance on the market in Germany and Europe. This includes<br><br>(a) heat generation from biogenic solid fuels in small and large-scale plants<br><br>(b) power generation from solid biomass via combustion<br><br>(c) a biogas production from residues, by-products and waste,<br><br>(d) alcohol production from sugar and starch<br><br>(e) biodiesel production from vegetable oils.<br><br>Special attention is also paid to the corresponding environmental aspects. An economic classification of the various options is also provided. |
| **Literature** | Unterlagen der Vorlesung |

## Module M1753: Practical module 4 (dual study program, Bachelor's degree)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical term 4 (dual study program, Bachelor's degree) (L2882) | | 0 | 6 |

| | |
|---|---|
| **Module Responsible** | Dr. Henning Haschke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Successful completion of practical module 3 as part of the dual Bachelor's course<br>• course B from the module on interlinking theory and practice as part of the dual Bachelor's course |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students ...<br>• ... understand the company's strategic orientation, as well as the functions and organisation of central departments with their decision-making structures, network relationships, and relevant company communication.<br>• ... have developed an understanding of the requirements and responsibilities of the engineering profession, know the scope and limits of the professional field of activity.<br>• ... can combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity. |
| *Skills* | Dual students ...<br>• ... apply technical theoretical knowledge to current problems in their own field of work, and evaluate work processes and results, taking into account different possible courses of action.<br>• ... use technology, equipment and resources in accordance with the assigned work areas and tasks, and can assess operational processes and procedures with regard to the intended work results/objectives.<br>• ... implement the university's application recommendations in relation to their current tasks. |
| **Personal Competence** | |
| *Social Competence* | Dual students ...<br>• ... are able to plan work processes cooperatively, across work areas and in heterogeneous groups.<br>• ... communicate professionally with operational stakeholders and present complex issues in a structured, targeted and convincing manner. |
| *Autonomy* | Dual students ...<br>• ... assume responsibility for work assignments and areas, and coordinate the associated work processes.<br>• ... document and reflect on the relevance of subject modules and specialisations for work as an engineer, as well as the implementation of the university's application recommendations and the associated challenges of a positive transfer of knowledge between theory and practice. |
| **Workload in Hours** | Independent Study Time 180, Study Time in Lecture 0 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase. |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Computer Science: Core Qualification: Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Engineering Science: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| Course L2882: Practical term 4 (dual study program, Bachelor's degree) | |
|---|---|
| **Typ** | |
| **Hrs/wk** | 0 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 180, Study Time in Lecture 0 |
| **Lecturer** | Dr. Henning Haschke |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | **Company onboarding process**<br>• Assigning work area(s)<br>• Extending responsibilities and authorisations of the dual student within the company<br>• Independent work tasks and areas<br>• Participating in project teams<br>• Scheduling the relevant practical module<br>• Theory/practice transfer options<br>• Scheduling the examination phase/subsequent study semester<br>**Operational knowledge and skills**<br>• Company-specific: strategic direction, organisation of central business and work areas, departments, decision-making structures, network relationships and internal communication<br>• Linking facts, principles and theories with practical knowledge<br>• Process and procedure options within the labour-market-relevant field of engineering<br>• Operational technology, equipment and resources<br>• Implementing the university’s application recommendations (theory-practice transfer) in corresponding work and task areas across the company<br>**Sharing/reflecting on learning**<br>• E-portfolio<br>• Relevance of subject modules and specialisations when working as an engineer<br>• University application recommendations for transferring knowledge between theory and practice |
| **Literature** | • Studierendenhandbuch<br>• Betriebliche Dokumente<br>• Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer |

## Module M0538: Heat and Mass Transfer

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Heat and Mass Transfer (L0101) | Lecture | 2 | 2 |
| Heat and Mass Transfer (L0102) | Recitation Section (small) | 2 | 2 |
| Heat and Mass Transfer (L1868) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Irina Smirnova |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge: Technical Thermodynamics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • The students are capable of explaining qualitative and determining quantitative heat transfer in procedural apparatus (e. g. heat exchanger, chemical reactors).<br>• They are capable of distinguish and characterize different kinds of heat transfer mechanisms namely heat conduction, heat transfer and thermal radiation.<br>• The students have the ability to explain the physical basis for mass transfer in detail and to describe mass transfer qualitative and quantitative by using suitable mass transfer theories.<br>• They are able to depict the analogy between heat- and mass transfer and to describe complex linked processes in detail. |
| *Skills* | • The students are able to set reasonable system boundaries for a given transport problem by using the gained knowledge and to balance the corresponding energy and mass flow, respectively.<br>• They are capable to solve specific heat transfer problems (e.g. heated chemical reactors, temperature alteration in fluids) and to calculate the corresponding heat flows.<br>• Using dimensionless quantities, the students can execute scaling up of technical processes or apparatus.<br>• They are able to distinguish between diffusion, convective mass transition and mass transfer. They can use this knowledge for the description and design of apparatus (e.g. extraction column, rectification column).<br>• In this context, the students are capable to choose and design fundamental types of heat and mass exchanger for a specific application considering their advantages and disadvantages, respectively.<br>• In addition, they can calculate both, steady-state and non-steady-state processes in procedural apparatus.<br>• The students are capable to connect their knowledge obtained in this course with knowlegde of other courses (In particular the courses thermodynamics, fluid mechanics and chemical process engineering) to solve concrete technical problems. |
| **Personal Competence** | |
| *Social Competence* | • The students are capable to work on subject-specific challenges in teams and to present the results orally in a reasonable manner to tutors and other students. |
| *Autonomy* | • The students are able to find and evaluate necessary information from suitable sources<br>• They are able to prove their level of knowledge during the course with accompanying procedure continuously (clicker-system, exam-like assignments) and on this basis they can control their learning processes. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes; theoretical questions and calculations |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0101: Heat and Mass Transfer | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 1. Heat transfer<br>  ◦ Introduction, one-dimensional heat conduction<br>  ◦ Convective heat transfer<br>  ◦ Multidimensional heat conduction<br>  ◦ Non-steady heat conduction<br>  ◦ Thermal radiation<br>2. Mass transfer<br>  ◦ one-way diffusion, equimolar countercurrent diffusion<br>  ◦ boundary layer theory, non-steady mass transfer<br>  ◦ Heat and mass transfer single particle/ fixed bed<br>  ◦ Mass transfer and chemical reactions |
| **Literature** | 1. H.D. Baehr und K. Stephan: Wärme- und Stoffübertragung, Springer<br>2. VDI-Wärmeatlas |

| Course L0102: Heat and Mass Transfer | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1868: Heat and Mass Transfer | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0833: Introduction to Control Systems

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Control Systems (L0654) | Lecture | 2 | 4 |
| Introduction to Control Systems (L0655) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Timm Faulwasser |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Representation of signals and systems in time and frequency domain, Laplace transform |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can represent dynamic system behavior in time and frequency domain, and can in particular explain properties of first and second order systems<br>• They can explain the dynamics of simple control loops and interpret dynamic properties in terms of frequency response and root locus<br>• They can explain the Nyquist stability criterion and the stability margins derived from it.<br>• They can explain the role of the phase margin in analysis and synthesis of control loops<br>• They can explain the way a PID controller affects a control loop in terms of its frequency response<br>• They can explain issues arising when controllers designed in continuous time domain are implemented digitally |
| *Skills* | • Students can transform models of linear dynamic systems from time to frequency domain and vice versa<br>• They can simulate and assess the behavior of systems and control loops<br>• They can design PID controllers with the help of heuristic (Ziegler-Nichols) tuning rules<br>• They can analyze and synthesize simple control loops with the help of root locus and frequency response techniques<br>• They can calculate discrete-time approximations of controllers designed in continuous-time and use it for digital implementation<br>• They can use standard software tools (Matlab Control Toolbox, Simulink) for carrying out these tasks |
| **Personal Competence** | |
| *Social Competence* | Students can work in small groups to jointly solve technical problems, and experimentally validate their controller designs |
| *Autonomy* | Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems.<br><br>They can assess their knowledge in weekly on-line tests and thereby control their learning progress. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Data Science: Specialisation II. Application: Elective Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Elective Compulsory<br>Logistics and Mobility: Specialisation Information Technology: Elective Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory |

| Course L0654: Introduction to Control Systems | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Timm Faulwasser |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Signals and systems<br>• Linear systems, differential equations and transfer functions<br>• First and second order systems, poles and zeros, impulse and step response<br>• Stability<br>Feedback systems<br>• Principle of feedback, open-loop versus closed-loop control<br>• Reference tracking and disturbance rejection<br>• Types of feedback, PID control<br>• System type and steady-state error, error constants<br>• Internal model principle<br>Root locus techniques<br>• Root locus plots<br>• Root locus design of PID controllers<br>Frequency response techniques<br>• Bode diagram<br>• Minimum and non-minimum phase systems<br>• Nyquist plot, Nyquist stability criterion, phase and gain margin<br>• Loop shaping, lead lag compensation<br>• Frequency response interpretation of PID control<br>Time delay systems<br>• Root locus and frequency response of time delay systems<br>• Smith predictor<br>Digital control<br>• Sampled-data systems, difference equations<br>• Tustin approximation, digital implementation of PID controllers<br>Software tools<br>• Introduction to Matlab, Simulink, Control toolbox<br>• Computer-based exercises throughout the course |
| **Literature** | • Werner, H., Lecture Notes „Introduction to Control Systems“<br>• G.F. Franklin, J.D. Powell and A. Emami-Naeini "Feedback Control of Dynamic Systems", Addison Wesley, Reading, MA, 2009<br>• K. Ogata "Modern Control Engineering", Fourth Edition, Prentice Hall, Upper Saddle River, NJ, 2010<br>• R.C. Dorf and R.H. Bishop, "Modern Control Systems", Addison Wesley, Reading, MA 2010 |

| Course L0655: Introduction to Control Systems | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Timm Faulwasser |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1754: Practical module 5 (dual study program, Bachelor's degree)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical term 5 (dual study program, Bachelor's degree) (L2883) | | 0 | 6 |

| | |
|---|---|
| **Module Responsible** | Dr. Henning Haschke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Successful completion of practical module 4 as part of the dual Bachelor’s course<br>• course C from the module on interlinking theory and practice as part of the dual Bachelor’s course |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students ...<br>• ... combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity.<br>• ... have a critical understanding of the practical applications of their engineering subject. |
| *Skills* | Dual students ...<br>• ... apply technical theoretical knowledge to complex, interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action.<br>• ... implement the university’s application recommendations with regard to their current tasks.<br>• ... develop new solutions as well as procedures and approaches in their field of activity and area of responsibility - including in the case of frequently changing requirements (systemic skills).<br>• ... are able to analyse and evaluate operational issues using academic methods. |
| **Personal Competence** | |
| *Social Competence* | Dual students ...<br>• ... work responsibly in operational project teams and proactively deal with problems within their team.<br>• ... represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and external stakeholders and develop these further together. |
| *Autonomy* | Dual students ...<br>• ... define goals for their own learning and working processes as engineers.<br>• ... document and reflect on learning and work processes in their area of responsibility.<br>• ... document and reflect on the relevance of subject modules, specialisations and research for work as an engineer, as well as the implementation of the university’s application recommendations and the associated challenges of a positive transfer of knowledge between theory and practice. |
| **Workload in Hours** | Independent Study Time 180, Study Time in Lecture 0 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the dual@TUHH Coordination Office that the dual student has completed the practical phase. |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Computer Science: Core Qualification: Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Engineering Science: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| Course L2883: Practical term 5 (dual study program, Bachelor's degree) | |
|---|---|
| **Typ** | |
| **Hrs/wk** | 0 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 180, Study Time in Lecture 0 |
| **Lecturer** | Dr. Henning Haschke |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | **Company onboarding process**<br>• Assigning a future professional field of activity as an engineer (B.Sc.) and associated areas of work<br>• Extending responsibilities and authorisations of the dual student within the company up to the intended first assignment after completing their studies or to the assignment completed during the subsequent dual Master's course<br>• Taking personal responsibility within a team - in their own area of responsibility and across departments<br>• Scheduling the final practical module with a clear correlation to work structures<br>• Internal agreement on a potential topic for the Bachelor's dissertation<br>• Planning the Bachelor's dissertation within the company in cooperation with TU Hamburg<br>• Scheduling the examination phase/sixth study semester<br>**Operational knowledge and skills**<br>• Company-specific: dealing with change, team development, responsibility as an engineer in their own future field of work (B.Sc.), dealing with complex contexts and unresolved problems, developing and implementing innovative solutions<br>• Specialising in one field of work (final dissertation)<br>• Systemic skills<br>• Implementing the university's application recommendations (theory-practice transfer) in corresponding work and task areas across the company<br>**Sharing/reflecting on learning**<br>• E-portfolio<br>• Relevance of subject modules and specialisations when working as an engineer<br>• Importance of research and innovation when working as an engineer<br>• University application recommendations for transferring knowledge between theory and practice |
| **Literature** | • Studierendenhandbuch<br>• Betriebliche Dokumente<br>• Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer |

## Module M1775: Economic and environmental project assessment

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Case studies economic and environmental project assessment (L1054) | Recitation Section (small) | 1 | 1 |
| Basics of Environmental Project Assessment (L0860) | Lecture | 2 | 2 |
| Basics of economic project assement (L2918) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | On completion of this module, students will be able to analyze and evaluate projects / project ideas from an economic and environmental point of view; i.e. they will be able to systematize / analyze an intended / planned project on the basis of certain criteria and then, with the help of economic and environmental instruments, evaluate such planned projects on the basis of the specific provision costs and selected environmental parameters. Such an approach includes a basic knowledge in the field of economic calculations (e.g. static and dynamic methods) on the one hand and a basic understanding in relation to the preparation of a life cycle assessment / an eco balance on the other hand. In addition, there is the knowledge to implement these instruments for corresponding specific use cases through balance boundaries to be drawn independently by the students and to interpret the results accordingly. |
| *Skills* | The students are able to apply the methods for an economic evaluation (e.g. annuity method) and for an environmental evaluation (e.g. life cycle assessment / eco balance) to different types of projects - and this related to various frame conditions. They will then be able to evaluate corresponding projects (including energy projects, chemical projects) in economic and environmental terms - and on the basis of this - in a systemic manner, and to make statements about the corresponding economic and environmental limitations. Additionally, students are able to orally explain issues from the subject area, approaches to dealing with them, and place them in their respective context. |
| **Personal Competence** | |
| *Social Competence* | Students are able to investigate suitable technical projects and ultimately evaluate them based on economic and environmental evaluation criteria - and thus finally under a wide range of sustainability aspects. |
| *Autonomy* | Students will be able to independently access various sources about the field, acquire knowledge, and transform it to address new issues. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory |

### Course L1054: Case studies economic and environmental project assessment

| | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Martin Kaltschmitt, Weitere Mitarbeiter |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | Skripte der Vorlesungen |

### Course L0860: Basics of Environmental Project Assessment

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Christoph Hagen Balzer |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | Skript der Vorlesung |

| Course L2918: Basics of economic project assement | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Andreas Wiese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction; definitions; significance of costs and economic calculations for projects; prices and costs; costs of systems versus costs of individual projects<br>• Cost estimates and cost calculations; definitions; cost calculation; cost estimation; calculation of costs for provision of work and power<br>• Economic calculation; definitions; methods: static methods, dynamic methods; project view versus view from the overall economy; power and work in economic calculation<br>• Consideration of uncertainties in projects; definitions; technical uncertainties; cost uncertainties; other uncertainties<br>• Cost projections; approaches and methods; assessment of uncertainties<br>• Project financing; definitions; project versus corporate financing; financing models; equity ratio, DSCR; addressing risks in project financing |
| **Literature** | Skript der Vorlesung |

# Specialization Biotechnologies

In the specialisation "Bioresource Technology", process engineering and biotechnological contents and competences are combined in a comprehensive subject area. The students gain a deeper understanding of the interactions and interfaces between bioresources and process engineering for the establishment of a sustainable bioeconomy.

## Module M0546: Thermal Separation Processes

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Thermal Separation Processes (L0118) | Lecture | 2 | 2 |
| Thermal Separation Processes (L0119) | Recitation Section (small) | 2 | 2 |
| Thermal Separation Processes (L0141) | Recitation Section (large) | 1 | 1 |
| Separation Processes (L1159) | Practical Course | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Irina Smirnova |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Recommended requirements: Thermodynamics III |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • The students can distinguish and describe different types of separation processes such as distillation, extraction, and adsorption<br>• The students develop an understanding for the course of concentration during a separation process, the estimation of the energy demand of a process, the possibilities of energy saving, and the selection of separation systems<br>• They have good knowledge of designing methods for separation processes and devices |
| *Skills* | • Using the gained knowledge the students can select a reasonable system boundary for a given separation process and can close the associated energy and material balances<br>• The students can use different graphical methods for the designing of a separation process and define the amount of theoretical stages required<br>• They can select and design a basic type of thermal separation process for a given case based on the advantages and disadvantages of the process<br>• The students are capable to obtain independently the needed material properties from appropriate sources (diagrams and tables)<br>• They can calculate continuous and discontinuous processes<br>• The students are able to prove their theoretical knowledge in the experimental lab work.<br>• The students are able to discuss the theoretical background and the content of the experimental work with the teachers in colloquium.<br><br>The students are capable of linking their gained knowledge with the content of other lectures and use it together for the solution of technical problems. Other lectures such as thermodynamics, fluid mechanics and chemical engineering. |
| **Personal Competence** | |
| *Social Competence* | • The students can work technical assignments in small groups and present the combined results in the tutorial<br>• The students are able to carry out practical lab work in small groups and organize a functional division of labor between them. They are able to discuss their results and to document them scientifically in a report. |
| *Autonomy* | • The students are capable to obtain the needed information from suitable sources by themselves and assess their quality<br>• The students can proof the state of their knowledge with exam resembling assignments and in this way control their learning process |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes; theoretical questions and calculations |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory |

| | |
|---|---|
| | Process Engineering: Core Qualification: Compulsory |

| **Course L0118: Thermal Separation Processes** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction in the thermal process engineering and to the main features of separation processes<br>• Simple equilibrium processes, several steps processes<br>• Distillation of binary mixtures, enthalpy-concentration diagrams<br>• Extractive and azeotrope distillation, water vapor distillation, stepwise distillation<br>• Extraction: separation ternary systems, ternary diagram<br>• Multiphase separation including complex mixtures<br>• Designing of separation devices without discrete stages<br>• Drying<br>• Chromatographic separation processes<br>• Membrane separation<br>• Energy demand of separation processes<br>• Advance overview of separation processes<br>• Selection of separation processes |
| **Literature** | • G. Brunner: Skriptum Thermische Verfahrenstechnik<br>• J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980<br>• Sattler: Thermische Trennverfahren, VCH, Weinheim 1995<br>• J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998.<br>• Mersmann: Thermische Verfahrenstechnik, Springer, 1980<br>• Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997<br>• Brunner, G.: Gas extraction. An introduction to fundamentals of supercritical fluids and the application to separation processes. Steinkopff, Darmstadt; Springer, New York; 1994. ISBN 3-7985-0944-1 ; ISBN 0-387-91477-3 .<br>• R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006.<br>  ◦ Perry"s Chemical Engineers" Handbook, R.H. Perry, D.W. Green, J.O. Maloney (Hrsg.), 6th ed., McGraw-Hill, New York 1984 Ullmann"s Enzyklopädie der Technischen Chemie |

| **Course L0119: Thermal Separation Processes** | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction in the thermal process engineering and to the main features of separation processes<br>• Simple equilibrium processes, several steps processes<br>• Distillation of binary mixtures, enthalpy-concentration diagrams<br>• Extractive and azeotrope distillation, water vapor distillation, stepwise distillation<br>• Extraction: separation ternary systems, ternary diagram<br>• Multiphase separation including complex mixtures<br>• Designing of separation devices without discrete stages<br>• Drying<br>• Chromatographic separation processes<br>• Membrane separation<br>• Energy demand of separation processes<br>• Advance overview of separation processes<br>• Selection of separation processes<br><br>The students work on tasks in small groups and present their results in front of all students. |
| **Literature** | • G. Brunner: Skriptum Thermische Verfahrenstechnik<br>• J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980<br>• Sattler: Thermische Trennverfahren, VCH, Weinheim 1995<br>• J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998.<br>• Mersmann: Thermische Verfahrenstechnik, Springer, 1980<br>• Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997<br>• Brunner, G.: Gas extraction. An introduction to fundamentals of supercritical fluids and the application to separation processes. Steinkopff, Darmstadt; Springer, New York; 1994. ISBN 3-7985-0944-1 ; ISBN 0-387-91477-3 .<br>• R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006.<br>• Perry"s Chemical Engineers" Handbook, R.H. Perry, D.W. Green, J.O. Maloney (Hrsg.), 6th ed., McGraw-Hill, New York 1984 Ullmann"s Enzyklopädie der Technischen Chemie |

| Course L0141: Thermal Separation Processes | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction in the thermal process engineering and to the main features of separation processes<br>• Simple equilibrium processes, several steps processes<br>• Distillation of binary mixtures, enthalpy-concentration diagrams<br>• Extractive and azeotrope distillation, water vapor distillation, stepwise distillation<br>• Extraction: separation ternary systems, ternary diagram<br>• Multiphase separation including complex mixtures<br>• Designing of separation devices without discrete stages<br>• Drying<br>• Chromatographic separation processes<br>• Membrane separation<br>• Energy demand of separation processes<br>• Advance overview of separation processes<br>• Selection of separation processes |
| **Literature** | • G. Brunner: Skriptum Thermische Verfahrenstechnik<br>• J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980<br>• Sattler: Thermische Trennverfahren, VCH, Weinheim 1995<br>• J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998.<br>• Mersmann: Thermische Verfahrenstechnik, Springer, 1980<br>• Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997<br>• Brunner, G.: Gas extraction. An introduction to fundamentals of supercritical fluids and the application to separation processes. Steinkopff, Darmstadt; Springer, New York; 1994. ISBN 3-7985-0944-1 ; ISBN 0-387-91477-3 .<br>• R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006.<br>• Perry"s Chemical Engineers" Handbook, R.H. Perry, D.W. Green, J.O. Maloney (Hrsg.), 6th ed., McGraw-Hill, New York 1984 Ullmann"s Enzyklopädie der Technischen Chemie |

| Course L1159: Separation Processes | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | The students work on eight different experiments in this practical course. For every one of the eight experiments, a colloquium takes place in which the students explain and discuss the theoretical background and its translation into practice with staff and fellow students.<br><br>The students work small groups with a high degree of division of labor. For every experiment, the students write a report. They receive instructions in terms of scientific writing as well as feedback on their own reports and level of scientific writing so they can increase their capabilities in this area.<br><br>Topics of the practical course:<br><br>• Introduction in the thermal process engineering and to the main features of separation processes<br>• Simple equilibrium processes, several steps processes<br>• Distillation of binary mixtures, enthalpy-concentration diagrams<br>• Extractive and azeotrope distillation, water vapor distillation, stepwise distillation<br>• Extraction: separation ternary systems, ternary diagram<br>• Multiphase separation including complex mixtures<br>• Designing of separation devices without discrete stages<br>• Drying<br>• Chromatographic separation processes<br>• Membrane separation<br>• Energy demand of separation processes<br>• Advance overview of separation processes<br>• Selection of separation processes |
| **Literature** | • G. Brunner: Skriptum Thermische Verfahrenstechnik<br>• J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980<br>• Sattler: Thermische Trennverfahren, VCH, Weinheim 1995<br>• J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998.<br>• Mersmann: Thermische Verfahrenstechnik, Springer, 1980<br>• Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997<br>• Brunner, G.: Gas extraction. An introduction to fundamentals of supercritical fluids and the application to separation processes. Steinkopff, Darmstadt; Springer, New York; 1994. ISBN 3-7985-0944-1 ; ISBN 0-387-91477-3 .<br>• R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006.<br>• Perry"s Chemical Engineers" Handbook, R.H. Perry, D.W. Green, J.O. Maloney (Hrsg.), 6th ed., McGraw-Hill, New York 1984 Ullmann"s Enzyklopädie der Technischen Chemie |

## Module M0892: Chemical Reaction Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Chemical Reaction Engineering (Fundamentals) (L0204) | Lecture | 2 | 2 |
| Chemical Reaction Engineering (Fundamentals) (L0244) | Recitation Section (large) | 2 | 2 |
| Experimental Course Chemical Engineering (Fundamentals) (L0221) | Practical Course | 2 | 2 |

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|---|---|
| **Module Responsible** | Prof. Raimund Horn |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Contents of the previous modules mathematics I-III, physical chemistry, technical thermodynamics I+II as well as computational methods for engineers. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to explain basic concepts of chemical reaction engineering. They are able to point out differences between thermodynamical and kinetical processes. The students have a strong ability to outline parts of isothermal and non-isothermal ideal reactors and to describe their properties. |
| *Skills* | After successful completion of the module, students are able to:<br>- apply different computational methods to dimension isothermal and non-isothermal ideal reactors,<br>- determine and compute stable operation points for these reactors ,<br>- conduct experiments on a lab-scale pilot plants and document these according to scientific guidelines. |
| **Personal Competence** | |
| *Social Competence* | After successful completition of the lab-course the students have a strong ability to organize themselfes in small groups to solve issues in chemical reaction engineering. The students can discuss their subject related knowledge among each other and with their teachers. |
| *Autonomy* | The students are able to obtain further information and assess their relevance autonomously. Students can apply their knowldege discretely to plan, prepare and conduct experiments. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / None / Subject theoretical and practical work |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

### Course L0204: Chemical Reaction Engineering (Fundamentals)

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|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Raimund Horn |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Fundamentals of chemical reaction engineering, definitions, calculation of species concentrations (reactor, reaction mixture, reactants, products, inerts and solvents, reaction volume, Reaktor volume, chemical reaction, mass, moles, mole fraction, volume, density, molar concentration, mass-concentration, molality, partial pressure, hydrodynamic residence time, space time, extent of reaction, reactor throughput, reactor load, conversion, selectivity, yield, concentration calculations in stationary and flowing multicomponent-mixtures)<br><br>Stoichiometry and stoichiometric calculations (simple reactions, complex reactions, key reactions, key species, matrix of stoichiometric coefficients, linear dependent and independent reactions, element-species-matrix, row reduced form of a matrix, rank of a matrix, Gauss Jordan elimination, relation between stoichiometry and kinetics, calculating the extent of reaction from mole number changes in complex reactions)<br><br>Thermodynamics (What is thermodynamics?, importance of thermodynamics in chemical reaction engineering, zeroth law of thermodynamics, temperature scales, temperature measurements in praxis, first law of thermodynamics, internal energy, enthalpy, calorimeter, heat of reaction, standard heat of formation, Hess law, heat capacity, Kirchhoff law, standard heat of reaction, pressure dependence of the heat of reaction, second law of thermodynamics, reversible and irreversible processes, entropy, Clausius inequality, free energy, Gibbs Energy, chemical potential, chemical equilibrium, activity, van't Hoff law, calculation of chemical equilibrium, principle of Le Chatelier and Braun, equilibrium calculations in multiple reaction systems, Lagrange Multipliers)<br><br>Chemical kinetics (reversible and irreversible reactions, homogeneous and heterogeneous reactions, elementary step, reaction mechanism, microkinetics, macrokinetics, formal kinetics, reaction rate, rate of change of species mole number, Arrhenius-equation, activation energy and pre-exponential factor for komplex reactions, reactions of 0., 1. and 2. order, analytical integration |

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| | of rate laws, Damköhler-number, differential and integral method of kinetic analysis, laboratory reactors for kinetic measurements, half life, kinetics of complex reactions, parallel reactions, reversible reactions, sequence of reactions, irreversible reaction with pre-equilibrium, reduction of reaction mechanisms, quasi-stationarity principle of Bodenstein, rate limiting step, Michaelis-Menten kinetics, analytical integration of first order differential equations - integrating factor, numerical integration of complex kinetics)<br><br>Types of chemical Reaktors (chemical reactors in industry and laboratory, ideal vs. real reaktors, discontinuous, half continuous and continuous reactors, single phase - biphasic- and multiphase reactors, batch-reactor, semi-batch reactor, CSTR, Plug Flow reactor, fixed bed reactor, adiabatic staged reactors, rotating furnaces, fluidized bed reactors, gas-liquid-reactors, multi-phase reactors)<br><br>Isothermal ideal reactors (mole-balance of a chemical reactor, mole balance of a batch reactor, integration of the batch reactor mole balance for various kinetics, partial fraction decomposition, mole balance of the semi-batch reactor, mole balance of the plug flow reactor, analogy batch reactor - plug flow reactor, design of plug flow reactors for reactions with volume change and complex reactions, mole balance of a fixed bed reactor, design of a membrane reactor, mole balance of a continuously stirred tank reactor, comparison of CSTR and PFR with respect to conversion and selectivity, mole-balance of a cascade of tank reactors, numerical-interative calculation of a cascade of tank reactors, Newton-Raphson method, graphical analysis of a cascade of tank reactors)<br><br>non-isothermal ideal reactors (energy balance of a reactor, adiabatic reactor, adiabatic temperature rise, staged reactor for adiabatic exothermic reactions limited by chemical equilibrium, design of an adiabatic plug flow reactor, Levenspiel-plots, heat transfer through a reactor wall, heat transfer by convection, heat conduction, heat transfer through a cylindrical wall, design of a plug flow reactor in parallel and counter flow, heat balance of the cooling fluid, CSTR with heat exchange, multiple stationary states, ignition-extinction behavior, stability of a CSTR, complex reactions in non-isothermal reactors, optimum temperature profile of a reactor) |
| **Literature** | lecture notes Raimund Horn<br><br>skript Frerich Keil<br><br>Books:<br><br>M. Baerns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, Technische Chemie, Wiley-VCH<br><br>G. Emig, E. Klemm, Technische Chemie, Springer<br><br>A. Behr, D. W. Agar, J. Jörissen, Einführung in die Technische Chemie<br><br>E. Müller-Erlwein, Chemische Reaktionstechnik 2012, 2. Auflage, Teubner Verlag<br><br>J. Hagen, Chemiereaktoren: Auslegung und Simulation, 2004, Wiley-VCH<br><br>H. S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall B<br><br>H. S. Fogler, Essentials of Chemical Reaction Engineering, Prentice Hall<br><br>O. Levenspiel, Chemical Reaction Engineering, John Wiley & Sons, 1998<br><br>L. D. Schmidt, The Engineering of Chemical Reactions, Oxford Univ. Press, 2009<br><br>J. B. Butt, Reaction Kinetics and Reactor Design, 2000, Marcel Dekker<br><br>R. Aris, Elementary Chemical Reactor Analysis, Dover Pubn. Inc., 2000<br><br>M. E. Davis, R. J. Davis, Fundamentals of Chemical Reaction Engineering, McGraw Hill<br><br>G. F. Froment, K. B. Bischoff, J. De Wilde, Chemical Reactor Analysis and Design, John Wiley & Sons, 2010<br><br>A. Jess, P. Wasserscheid, Chemical Technology An Integrated Textbook, WILEY-VCH |

| **Course L0244: Chemical Reaction Engineering (Fundamentals)** | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Raimund Horn, Dr. Oliver Korup |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Fundamentals of chemical reaction engineering, definitions, calculation of species concentrations (reactor, reaction mixture, reactants, products, inerts and solvents, reaction volume, Reaktor volume, chemical reaction, mass, moles, mole fraction, volume, density, molar concentration, mass-concentration, molality, partial pressure, hydrodynamic residence time, space time, extent of reaction, reactor throughput, reactor load, conversion, selectivity, yield, concentration calculations in stationary and flowing multicomponent-mixtures)<br><br>Stoichiometry and stoichiometric calculations (simple reactions, complex reactions, key reactions, key species, matrix of stoichiometric coefficients, linear dependent and independent reactions, element-species-matrix, row reduced form of a matrix, rank of a matrix, Gauss Jordan elimination, relation between stoichiometry and kinetics, calculating the extent of reaction from mole number changes in complex reactions)<br><br>Thermodynamics (What is thermodynamics?, importance of thermodynamics in chemical reaction engineering, zeroth law of thermodynamics, temperature scales, temperature measurements in praxis, first law of thermodynamics, internal energy, |

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|---|---|
| | enthalpy, calorimeter, heat of reaction, standard heat of formation, Hess law, heat capacity, Kirchhoff law, standard heat of reaction, pressure dependence of the heat of reaction, second law of thermodynamics, reversible and irreversible processes, entropy, Clausius inequality, free energy, Gibbs Energy, chemical potential, chemical equilibrium, activity, van't Hoff law, calculation of chemical equilibrium, principle of Le Chatelier and Braun, equilibrium calculations in multiple reaction systems, Lagrange Multipliers)<br><br>Chemical kinetics (reversible and irreversible reactions, homogeneous and heterogeneous reactions, elementary step, reaction mechanism, microkinetics, macrokinetics, formal kinetics, reaction rate, rate of change of species mole number, Arrhenius-equation, activation energy and pre-exponential factor for komplex reactions, reactions of 0., 1. and 2. order, analytical integration of rate laws, Damköhler-number, differential and integral method of kinetic analysis, laboratory reactors for kinetic measurements, half life, kinetics of complex reactions, parallel reactions, reversible reactions, sequence of reactions, irreversible reaction with pre-equilibrium, reduction of reaction mechanisms, quasi-stationarity principle of Bodenstein, rate limiting step, Michaelis-Menten kinetics, analytical integration of first order differential equations - integrating factor, numerical integration of complex kinetics)<br><br>Types of chemical Reaktors (chemical reactors in industry and laboratory, ideal vs. real reaktors, discontinuous, half continuous and continuous reactors, single phase - biphasic- and multiphase reactors, batch-reactor, semi-batch reactor, CSTR, Plug Flow reactor, fixed bed reactor, adiabatic staged reactors, rotating furnaces, fluidized bed reactors, gas-liquid-reactors, multi-phase reactors)<br><br>Isothermal ideal reactors (mole-balance of a chemical reactor, mole balance of a batch reactor, integration of the batch reactor mole balance for various kinetics, partial fraction decomposition, mole balance of the semi-batch reactor, mole balance of the plug flow reactor, analogy batch reactor - plug flow reactor, design of plug flow reactors for reactions with volume change and complex reactions, mole balance of a fixed bed reactor, design of a membrane reactor, mole balance of a continuously stirred tank reactor, comparison of CSTR and PFR with respect to conversion and selectivity, mole-balance of a cascade of tank reactors, numerical-interative calculation of a cascade of tank reactors, Newton-Raphson method, graphical analysis of a cascade of tank reactors)<br><br>non-isothermal ideal reactors (energy balance of a reactor, adiabatic reactor, adiabatic temperature rise, staged reactor for adiabatic exothermic reactions limited by chemical equilibrium, design of an adiabatic plug flow reactor, Levenspiel-plots, heat transfer through a reactor wall, heat transfer by convection, heat conduction, heat transfer through a cylindrical wall, design of a plug flow reactor in parallel and counter flow, heat balance of the cooling fluid, CSTR with heat exchange, multiple stationary states, ignition-extinction behavior, stability of a CSTR, complex reactions in non-isothermal reactors, optimum temperature profile of a reactor) |
| **Literature** | lecture notes Raimund Horn<br><br>skript Frerich Keil<br><br>Books:<br><br>M. Baerns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, Technische Chemie, Wiley-VCH<br><br>G. Emig, E. Klemm, Technische Chemie, Springer<br><br>A. Behr, D. W. Agar, J. Jörissen, Einführung in die Technische Chemie<br><br>E. Müller-Erlwein, Chemische Reaktionstechnik 2012, 2. Auflage, Teubner Verlag<br><br>J. Hagen, Chemiereaktoren: Auslegung und Simulation, 2004, Wiley-VCH<br><br>H. S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall B<br><br>H. S. Fogler, Essentials of Chemical Reaction Engineering, Prentice Hall<br><br>O. Levenspiel, Chemical Reaction Engineering, John Wiley & Sons, 1998<br><br>L. D. Schmidt, The Engineering of Chemical Reactions, Oxford Univ. Press, 2009<br><br>J. B. Butt, Reaction Kinetics and Reactor Design, 2000, Marcel Dekker<br><br>R. Aris, Elementary Chemical Reactor Analysis, Dover Pubn. Inc., 2000<br><br>M. E. Davis, R. J. Davis, Fundamentals of Chemical Reaction Engineering, McGraw Hill<br><br>G. F. Froment, K. B. Bischoff, J. De Wilde, Chemical Reactor Analysis and Design, John Wiley & Sons, 2010<br><br>A. Jess, P. Wasserscheid, Chemical Technology  An Integrated Textbook, WILEY-VCH |

| Course L0221: Experimental Course Chemical Engineering (Fundamentals) | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Raimund Horn |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | Performing and evaluation of experiments concerning chemical reaction engineering with emphasis on ideal reactors:<br><br>* Batch reactor - Estimation of kinetic parameters for the saponification of ethylacetate<br><br>*CSTR - Residence time distribution, reaction<br><br>*CSTR in Series - Residence time distribution, reaction<br><br>* Plug Flow Reactor - Residence time distribution, reaction<br><br>Before the practical conduct of the experiments a colloquium takes place in which the students explain, reflect and discuss the theoretical basics and their translation into practice.<br><br>The students write up a report for every experiment. They receive feedback to their level of scientific writing (citation methods, labeling of graphs, etc.), so that they can improve their competence in this field over the course of the practical course. |
| **Literature** | Levenspiel, O.: Chemical reaction engineering; John Wiley & Sons, New York, 3. Ed., 1999 VTM 309(LB)<br><br>Praktikumsskript<br><br>Skript Chemische Verfahrenstechnik 1 (F.Keil) |

## Module M1713: Green Technologies III

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Study Work Green Technologies (L2766) | Project Seminar | 2 | 4 |
| Scientific Work and Writing (L2765) | Seminar | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Dozenten des Studiengangs |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | keine |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students, based on a literature survey, learn to study in detail a subject theme from the disciplines of green technologies and deliver afterwards a summary presentation to a specialised audience. Environmental issues and their multidisciplinary linkages are preferred, when selecting the thematic area of these studies. Through their own written contribution the students communicate an overview over the subject and practice technical writing. With the discussion the students practice scientific debating on a specialised subject matter. |
| *Skills* | The students can, when working on a technical topic not familiar to them:<br>• conduct a literature survey<br>• choose the relevant information for their presentation<br>• prepare a written summary<br>• present results in front of peers and staff<br>• correctly cite and reference sources. |
| **Personal Competence** | |
| *Social Competence* | The students practice a critical assessment of the literature in a predefined specialised theme and learn to give presentations on their own technical sub-topic tailored to their public and discuss with the audience. When attending technical presentations, the students can formulate questions to other speakers and participate in the ensuing discussion.<br>The fulfilment of the tasks combines independent work with group and teamwork. |
| *Autonomy* | The students can, guided by instructors, critically reflect on their learning and work status, and write a scientific report. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Study work |
| **Examination duration and scale** | - |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory |

### Course L2766: Study Work Green Technologies

| | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Studiengangs |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Students carry out a research project in a scientific field under the guidance of an academic staff member. For this purpose, the student can approach the staff of the respective institute and discuss a topic. The topic is then worked on within 4 weeks and regular consultations are held with the supervisor. The student research project should be the size of a scientific article and must be presented to the lecturer after completion as part of a presentation (approx. 15 minutes). |
| **Literature** | |

| Course L2765: Scientific Work and Writing | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Studiengangs, Dr. Detlev Bieler, Florian Hagen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The seminar offers an introduction into the diverse aspects of academic research and writing: Finding the topic, finding specialized information, knowledge organisation, writing, presenting and publishing. Suggestions for reflecting own processes of learning, informing and writing - in addition to practical recommendations and tips - facilitate the start and the creation of bachelor and master theses, works, which bring thoroughly self-fulfillment and make fun.<br><br>Topics of the seminar will be in particular<br><br>• Scientific scholarship and academic research methods:<br>• Introduction, organization, attributes of science:<br>How is scientific knowledge created?<br>Work scheduling, finding topics, time management, specialities of academic research in engineering<br>• Finding specialized information: Full texts and library resources, databases http://www.tub.tuhh.de/en/subject-information/informing-points-to-survive/<br>• Reference management: http://www.tub.tuhh.de/en/publishing/reference-management/<br>Knowledge organisation and creating publications with Citavi<br>• Citing correctly and avoiding plagiarism<br>• Preparing and doing presentations |
| **Literature** | 1. Semesterapparat "Wissenschaftliches Arbeiten" in der TU-Bibliothek: http://tinyurl.com/Semesterapparat-Wiss-Arbeiten<br>2. Weblog Wissenschaftliches Arbeiten der TU-Bibliothek: https://www.tub.tuhh.de/wissenschaftliches-arbeiten/<br>3. Online-Tutorial VISION der TU-Bibliothek zum wissenschaftlichen Arbeiten: https://www.vision.tuhh.de (funktioniert nur mit installiertem Flash)<br>4. Andreas Hirsch-Weber, Stefan Scherer: Wissenschaftliches Arbeiten und Abschlussarbeit in Natur- und Ingenieurwissenschaften : Grundlagen, Praxisbeispiele, Übungen. Stuttgart: Ulmer, 2016.<br>5. Werner Sesink: Einführung in das wissenschaftliche Arbeiten : inklusive E-Learning, Web-Recherche, digitale Präsentation u.a. 9., aktualisierte Aufl. München : Oldenbourg, 2012.<br>6. Judith Theuerkauf: Schreiben im Ingenieurstudium : effektiv und effizient zur Bachelor-, Master- und Doktorarbeit. Paderborn : Schöningh, 2012.<br>7. Wolfsberger, Judith: Frei geschrieben : Mut, Freiheit & Strategie für wissenschaftliche Abschlussarbeiten. Wien: Böhlau, 2010<br>8. Biedermann, Wieland u.a.: Forschungsmethodik in den Ingenieurwissenschaften : Skript vom Lehrstuhl für Produktentwicklung, Prof. Dr.-Ing. Udo Lindemann, Technische Universität München (TUM), 2012. https://www.mw.tum.de/fileadmin/w00btx/lpl/Documents/Forschungsmethodik_Skript.pdf<br>9. Wissenschaftliches Arbeiten - HOOU Angebot der HCU Hamburg: https://blogs.hoou.de/wissarbeiten/<br><br>1. Course Reserves Collection "Scholarly Research Methods" in the TUHH library: http://tinyurl.com/Semesterapparat-Wiss-Arbeiten<br>2. Scholarly research methods via TUHH library Website: https://www.tub.tuhh.de/en/scholarly-research-methods/<br>3. VISION - Online-Tutorial on research methods by the TUHH library: http://www.vision.tuhh.de (Flash has to be installed)<br>4. Scientific papers and presentations / Martha Davis. 3. ed. Amsterdam: Elsevier / Academic Press, 2013. http://www.sciencedirect.com/science/book/9780123847270<br>5. Writing for science and engineering : papers, presentations and reports / Heather Silyn-Roberts. 2nd ed. Amsterdam : Elsevier, 2013. http://www.sciencedirect.com/science/book/9780080982854<br>6. How to research / Loraine Blaxter, Christina Hughes and Malcolm Tight. Maidenhead : Open Univ. Press, 2010.<br>7. Managing information for research : practical help in researching, writing and designing dissertations / Elizabeth Orna and Graham Stevens. Maidenhead : Open University Press McGraw-Hill, 2009.<br>8. Writing scientific research articles : strategy and steps / Margaret Cargill and Patrick O'Connor. Chichester : Wiley-Blackwell, 2009. |

## Module M1761: Biological and Biochemical Fundamentals

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Biological and Biochemical Fundamentals (L2900) | Lecture | 2 | 2 |
| Fundamental Biological and Biochemical Practical Course (L2901) | Practical Course | 3 | 3 |
| Introduction to the Biological and Biochemical Practical Course (L2902) | Lecture | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Johannes Gescher |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | The module is divided into two parts. In the winter semester, a lecture with 2 semester hours per week is offered. No previous knowledge is required for this lecture. In the following summer semester, the second part of the module is offered. This is divided into an internship and an introductory lecture. For these two parts of the module, attendance of the lecture in the winter semester is strongly recommended. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The module aims to teach you the basic principles of biological systems and biocatalysts. You will learn how organisms are constructed and what basic characteristics can be used to distinguish organisms from the three kingdoms of life. You will learn about the ways in which biological systems can produce energy and you will apply the principles of biological thermodynamics. In addition, you will learn how enzymes are constructed and, using some classes of enzymes as examples, you will learn how enzymes exert their effect.<br><br>At the end of the module<br><br>- you will be able to describe basic principles of living systems and explain the metabolism of organisms by applying them.<br><br>- you will be able to assign organisms to the three kingdoms of life based on some basic characteristics<br><br>- you will be able to describe the tasks of enzymes generically on the basis of some example reactions<br><br>- you will be able to deduce from the basic characteristics of organisms and enzymes which biotechnological applications are possible with these systems.<br><br>- you can understand and use the technical vocabulary of biological systems and processes<br><br>- you will be able to perform simple bioinformatic operations to assign DNA sequences to a function<br><br>- you can confidently apply the basic principles of using primary literature |
| *Skills* | The students master the basic techniques of sterile work and molecular diagnostics. They can independently prepare media and maintain microorganisms in culture. In addition, they can isolate and characterize organisms from enrichment cultures and environmental samples. |
| **Personal Competence** | |
| *Social Competence* | The students are able,<br><br>- to gather knowledge in groups of about 2 to 10 students<br><br>- to introduce their own knowledge and to argue their view in discussions in teams<br><br>- to divide a complex task into subtasks, solve these and to present the combined results |
| *Autonomy* | Students are able to independently structure their internship days and prioritize tasks. Furthermore, they are able to collect and process basic information on microorganisms via a literature search. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / None / Presentation / Zusammenstellung der Ergebnisse des Praktikums |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L2900: Biological and Biochemical Fundamentals | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Johannes Gescher |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | In the lecture we will learn the basic characteristics of organisms of all kingdoms of life. This includes cell biology as well as cell physiology. We understand the energetic foundations of living systems and the variety of possible metabolic concepts of life. From these basic laws we will understand how and to what extent an application and genetic reprogramming of organisms for application can take place. |
| **Literature** | Fuchs: Allgemeine Mikrobiologie, 11. vollständig überarbeitete Auflage 2022; ISBN: 9783132434776<br>Brock: Biology of Microorganisms, ISBN-13: 9780134626109 |

| Course L2901: Fundamental Biological and Biochemical Practical Course | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Johannes Gescher |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The aim of the practical course is to teach basic microbiological and molecular biological techniques on the basis of individual research assignments and control experiments. In doing so, organisms are to be isolated in this practical course, which will be further processed by students of the 4th and 6th semester in two independent modules. |
| **Literature** | Steinbüchel: Mikrobiologisches Praktikum, ISBN: 978-3-662-63234-5 |

| Course L2902: Introduction to the Biological and Biochemical Practical Course | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Johannes Gescher |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The aim of the introductory lecture is to explain different methods used and their range of application. In addition, we will clarify specific physiological characteristics of the microorganisms to be isolated. |
| **Literature** | Steinbüchel: Mikrobiologisches Praktikum, ISBN: 978-3-662-63234-5 |

## Module M1764: Bioprocess Technology I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Bioprocess Technology I (L2906) | Lecture | 2 | 3 |
| Bioprocess Technology I (L2907) | Recitation Section (large) | 2 | 1 |
| Bioprocess Technology I - Fundamental Practical Course (L2908) | Practical Course | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Andreas Liese |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Content of module "Biological and Biochemical Fundamentals"<br>• Content of module “Organic Chemistry” |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Upon completion of the module, students will be able to:<br>• to describe basic processes of bioprocess engineering,<br>• to assign different types of kinetics to enzymes and microorganisms and to distinguish inhibition types,<br>• to name and describe the parameters of stoichiometry and rheology,<br>• to explain the mass transport processes in bioreactors fundamentally,<br>• to understand and describe the basics of bioprocess management (batch and continuously operated reactor types, calculation of the batch reaction time,...) in great detail,<br>• to explain methods for the retention of enzymes and microorganisms by immobilization in bioreactors. |
| *Skills* | After successful completion of this module, students should be able to<br>• using various kinetic approaches, to determine substrate turnover by enzymes as well as their kinetic parameters,<br>• describe the growth of whole cells with the help of different kinetic approaches as well as to determine their kinetic parameters,<br>• qualitatively predict the effects of enzyme inhibition on the behavior of enzymes and on the overall process,<br>• analyze and determine bioprocesses based on the stoichiometry of the reaction system,<br>• differentiate the various basic reactor types in biotechnological processes and select them specifically for the respective application,<br>• set up and solve mass balance and differential equations for the mathematical description of fermentation processes,<br>• apply various methods for determining mass transfer parameters for gases in solution and calculate the corresponding mass transfer coefficients |
| **Personal Competence** | |
| *Social Competence* | After completing the module, students are able to discuss scientific questions among themselves and with industry representatives in mixed teams, to represent their views on them and to work together on given engineering and scientific tasks. |
| *Autonomy* | After completion of this module participants are able to acquire new sources of knowledge and apply their knowledge to previously unknown issues and to present these. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** 5 %; **Form** Subject theoretical and practical work; **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L2906: Bioprocess Technology I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Andreas Liese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction to enzyme kinetics<br>• Immobilisation of enzymes and whole cells<br>• Stoichiometry of cell growth and product formation<br>• Microbial growth kinetics and growth models<br>• Maintenance metabolism<br>• Basic bioprocess reactor types<br>• Batch, fed-batch, chemostate and turbidostate fermentation<br>• Calculation of main parameters of fermentative processes<br>• Rheology and mechanical energy input<br>• Gassing of bioprocesses (aerobic and microaerobic)<br>• Discussion with bioprocess engineers of large and small companies, proportionally alumni of TUHH<br>• Repetitorium |
| **Literature** | A. Liese, K. Seelbach, C. Wandrey: Industrial Biotransformations, Wiley-VCH,2nd ed. 2006<br><br>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997<br><br>P. M. Doran: Bioprocess Engineering Principles, 2nd. edition, Academic Press, 2013<br><br>H. Chmiel, R. Takors, D. Weuster-Botz (Herausgeber): Bioprozeßtechnik, Springer Spektrum, 2018<br><br>K.-E. Jaeger, A. Liese, C. Syldatk: Einführung in die Enzymtechnologie, Springer, 2018 |

| Course L2907: Bioprocess Technology I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Andreas Liese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L2908: Bioprocess Technology I - Fundamental Practical Course | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Andreas Liese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out.<br><br>The students document their experiments and results in a protocol. |
| **Literature** | · Praktikumsskript bereitgestellt über StudIP<br><br>· Bioprozesstechnik-Vorlesung & -Vorlesungsskript<br><br>· Jaeger, K.-E., Liese, A., Syldatk, C. (2018). Einführung in die Enzymtechnologie. Springer Spektrum.<br><br>· Hilterhaus, L., Liese, A., Kettling, U., Antranikian, G. (2016). Applied Biocatalysis. Wiley-VCH.<br><br>· Hass, V. C., Pörtner, R. (2011). Praxis der Bioprozesstechnik mit virtuellem Praktikum. Spektrum Akademischer Verlag.<br><br>· Chmiel, H. (2018). Bioprozesstechnik. Springer Spektrum.<br><br>· Liese, A., Seelbach, K., Wandrey, C. (2006). Industrial Biotransformations. Wiley-VCH.<br><br>· Bommarius, S., Riebel, B. (2004). Biocatalysis: Fundamentals and Applications. Wiley-Blackwell.<br><br>· Schmid, R. D. (2003). Pocket Guide to Biotechnology and Genetic Engineering. Wiley-Blackwell. |

## Module M0829: Foundations of Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Management Tutorial (L0882) | Recitation Section (small) | 2 | 3 |
| Introduction to Management (L0880) | Lecture | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Christian Lüthje |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic Knowledge of Mathematics and Business |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After taking this module, students know the important basics of many different areas in Business and Management, from Planning and Organisation to Marketing and Innovation, and also to Investment and Controlling. In particular they are able to<br>• explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management<br>• explain the most important aspects of and goals in Management and name the most important aspects of entreprneurial projects<br>• describe and explain basic business functions as production, procurement and sourcing, supply chain management, organization and human ressource management, information management, innovation management and marketing<br>• explain the relevance of planning and decision making in Business, esp. in situations under multiple objectives and uncertainty, and explain some basic methods from mathematical Finance<br>• state basics from accounting and costing and selected controlling methods. |
| *Skills* | Students are able to analyse business units with respect to different criteria (organization, objectives, strategies etc.) and to carry out an Entrepreneurship project in a team. In particular, they are able to<br>• analyse Management goals and structure them appropriately<br>• analyse organisational and staff structures of companies<br>• apply methods for decision making under multiple objectives, under uncertainty and under risk<br>• analyse production and procurement systems and Business information systems<br>• analyse and apply basic methods of marketing<br>• select and apply basic methods from mathematical finance to predefined problems<br>• apply basic methods from accounting, costing and controlling to predefined problems |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• work successfully in a team of students<br>• to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project<br>• to communicate appropriately and<br>• to cooperate respectfully with their fellow students. |
| *Autonomy* | Students are able to<br>• work in a team and to organize the team themselves<br>• to write a report on their project. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | several written exams during the semester plus final test (90 minutes) |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Specialisation Biomechanics: Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Compulsory |

| | |
|---|---|
| | Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory<br>Mechanical Engineering: Specialisation Product Development and Production: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| **Course L0882: Management Tutorial** | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Lüthje, Katharina Roedelius |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | In the management tutorial, the contents of the lecture will be deepened by practical examples and the application of the discussed tools.<br><br>If there is adequate demand, a problem-oriented tutorial will be offered in parallel, which students can choose alternatively. Here, students work in groups on se selected projects that focus on the elaboration of an innovative business idea from the point of view of an established company or a startup. Again, the busin knowledge from the lecture should come to practical use. The group projects are guided by a mentor. |
| **Literature** | Relevante Literatur aus der korrespondierenden Vorlesung. |

| Course L0880: Introduction to Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Matthias Meyer, Prof. Christian Lüthje, Prof. Christian Ringle, Prof. Christian Thies, Prof. Christoph Ihl, Prof. Kathrin Fischer, Prof. Moritz Göldner, Prof. Thomas Wrona, Prof. Thorsten Blecker, Prof. Tim Schweisfurth, Prof. Wolfgang Kersten |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | • Introduction to Business and Management, Business versus Economics, relevant areas in Business and Management<br>• Important definitions from Management,<br>• Developing Objectives for Business, and their relation to important Business functions<br>• Business Functions: Functions of the Value Chain, e.g. Production and Procurement, Supply Chain Management, Innovation Management, Marketing and Sales<br>Cross-sectional Functions, e.g. Organisation, Human Ressource Management, Supply Chain Management, Information Management<br>• Definitions as information, information systems, aspects of data security and strategic information systems<br>• Definition and Relevance of innovations, e.g. innovation opporunities, risks etc.<br>• Relevance of marketing, B2B vs. B2C-Marketing<br>• different techniques from the field of marketing (e.g. scenario technique), pricing strategies<br>• important organizational structures<br>• basics of human ressource management<br>• Introduction to Business Planning and the steps of a planning process<br>• Decision Analysis: Elements of decision problems and methods for solving decision problems<br>• Selected Planning Tasks, e.g. Investment and Financial Decisions<br>• Introduction to Accounting: Accounting, Balance-Sheets, Costing<br>• Relevance of Controlling and selected Controlling methods<br>• Important aspects of Entrepreneurship projects |
| **Literature** | Bamberg, G., Coenenberg, A.: Betriebswirtschaftliche Entscheidungslehre, 14. Aufl., München 2008<br><br>Eisenführ, F., Weber, M.: Rationales Entscheiden, 4. Aufl., Berlin et al. 2003<br><br>Heinhold, M.: Buchführung in Fallbeispielen, 10. Aufl., Stuttgart 2006.<br><br>Kruschwitz, L.: Finanzmathematik. 3. Auflage, München 2001.<br><br>Pellens, B., Fülbier, R. U., Gassen, J., Sellhorn, T.: Internationale Rechnungslegung, 7. Aufl., Stuttgart 2008.<br><br>Schweitzer, M.: Planung und Steuerung, in: Bea/Friedl/Schweitzer: Allgemeine Betriebswirtschaftslehre, Bd. 2: Führung, 9. Aufl., Stuttgart 2005.<br><br>Weber, J., Schäffer, U. : Einführung in das Controlling, 12. Auflage, Stuttgart 2008.<br><br>Weber, J./Weißenberger, B.: Einführung in das Rechnungswesen, 7. Auflage, Stuttgart 2006. |

## Module M1969: Conceptual Process Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Conceptual Process Design (L3217) | Lecture | 2 | 3 |
| Conceptual Process Design (L3218) | Recitation Section (large) | 2 | 2 |
| Conceptual Process Design (L3219) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Mirko Skiborowski |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Process engineering fundamentals, in particular unit operations in mechanical and thermal process engineering and chemical reaction engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to<br>- classify and formulate global balance equations and linear material balance models for process engineering systems<br>- understand and apply system concepts<br>- explain and apply strategies for the synthesis of reactors in the synthesis of separation systems<br>- understand PINCH analyses<br>- specify static and dynamic methods of cost and profitability calculation<br><br>- Specify static and dynamic methods of cost and profitability calculation |
| *Skills* | Students are enabled to<br>- prepare mass and energy balances of processes and calculate the flows<br>- calculate mass flows in complex process engineering plants with the aid of linear material balance models<br>- solve balance equalization problems<br>- perform structured process synthesis for reactors<br>- perform structured process synthesis for separation systems<br>- Carry out PINCH analyses<br>- make quantitative statements about manufacturing costs and the economic efficiency of production processes |
| **Personal Competence** | |
| *Social Competence* | Students are able to develop solutions together in heterogeneous small groups |
| *Autonomy* | Students are enabled to acquire knowledge independently on the basis of further literature |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: Yes; Bonus: 10 %; Form: Subject theoretical and practical work<br>Compulsory: No; Bonus: 5 %; Form: Midterm |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L3217: Conceptual Process Design | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Mirko Skiborowski |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Methods and tools<br><br>- Global balances, flowsheets of processes, balance compensation and data validation<br><br>Process synthesis<br><br>- Structure of process engineering processes, decision levels in process development, reactor synthesis, synthesis of separation processes, alternatives and selection criteria, energy integration<br><br>Cost accounting and project management<br><br>Manufacturing costs, investment costs, economic evaluation and fundamentals of project management |
| **Literature** | |

| Course L3218: Conceptual Process Design | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Mirko Skiborowski |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L3219: Conceptual Process Design | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Mirko Skiborowski |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0544: Phase Equilibria Thermodynamics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Phase Equilibria Thermodynamics (L0114) | Lecture | 2 | 2 |
| Phase Equilibria Thermodynamics (L0140) | Recitation Section (small) | 1 | 2 |
| Phase Equilibria Thermodynamics (L0142) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Irina Smirnova |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics, Physical Chemistry, Thermodynamics I and II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Starting from the very basics of thermodynamics, the students learn the mathematical tools to describe thermodynamic equilibria.<br>• They learn how state variables are influenced by the mixing of compounds and learn concepts to quantitatively describe these properties.<br>• Moreover, the students learn how phase equilibria can be described mathematically and which phenomena may occur if different phases (vapor, liquid, solid) coexist in equilibrium. Furthermore the fundamentals of reaction equilibria are taught.<br>• For different phase equilibria, several examples relevant for different kinds of processes are shown and the necessary knowledge for plotting and interpreting the equilibria are taught. |
| *Skills* | • Applying their knowledge, the students are able to identify the correct equation for the determination of the equilibrium state and know how to simplify these equations meaningfully.<br>• The students know models which can be used to determine the properties of the system in the equilibrium state and they are able to solve the resulting mathematical relations.<br>• For specific applications, they are able to self-reliantly find necessary physico-chemical properties of compounds as well as model parameters in literature sources.<br>• Beside pure compound properties the students are capable of describing the properties of mixtures.<br>• The students know how to visualize phase equilibria graphically and they know how to interpret the occurring phenomena.<br>• Based on their knowledge, the students are able to understand fundamental concepts that are the basis for many separation and reaction processes in chemical engineering. |
| **Personal Competence** | |
| *Social Competence* | The students are able to work in small groups, to solve the corresponding problems and to present them oraly to the tutors and other students |
| *Autonomy* | • The students are able to find necessary information self-reliantly in literature sources and to judge their quality.<br>• During the semester the students are able to check their learning progress continuously in exercises. Based on this knowledge the students can adept their learning process. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes; theoretical questions and calculations |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0114: Phase Equilibria Thermodynamics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction: Applications of thermodynamics of mixtures<br>2. Thermodynamic equations in multi-component systems: Fundamental equations, chemical potential, fugacity<br>3. Phase equilibria of pure substances: thermodynamic equilibrium, vapor pressure, Gibbs' phase rule<br>4. Equations of state: virial equations, van-der-Waals equation, generalized equations of state<br>5. Mixing properties: ideal and real mixtures, excess properties, partial molar properties<br>6. Vapor-liquid-equilibria: binary systems, azeotropes, equilibrium condition<br>7. Gas-liquid-equilibria: equilibrium condition, Henry-coefficient<br>8. $G^E$-Models: Hildebrand-model, Flory-Huggins-model, Wilson-model, UNIQUAC, UNIFAC<br>9. Liquid-liquid-equilibria: equilibrium condition, phase equilibria in binary and ternary systems<br>10. Solid-liquid-equilibria: equilibrium condition, binary systems<br>11. Chemical reactions: reaction coordinate, mass action law, influence of pressure and temperature<br>12. Osmotic pressure |
| **Literature** | • Jürgen Gmehling, Bärbel Kolbe: Thermodynamik. VCH 1992<br>• J.M. Prausnitz, R.N. Lichtenthaler, E.G. de Azevedo: Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed. Prentice Hall, 1999.<br>• J.W. Tester, M. Modell: Thermodynamics and its Applications. 3 rd ed. Prentice Hall, 1997.J.P. O´Connell, J.M. Haile: Thermodynamics. Cambridge University Press, 2005. |

| Course L0140: Phase Equilibria Thermodynamics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction: Applications of thermodynamics of mixtures<br>2. Thermodynamic equations in multi-component systems: Fundamental equations, chemical potential, fugacity<br>3. Phase equilibria of pure substances: thermodynamic equilibrium, vapor pressure, Gibbs' phase rule<br>4. Equations of state: virial equations, van-der-Waals equation, generalized equations of state<br>5. Mixing properties: ideal and real mixtures, excess properties, partial molar properties<br>6. Vapor-liquid-equilibria: binary systems, azeotropes, equilibrium condition<br>7. Gas-liquid-equilibria: equilibrium condition, Henry-coefficient<br>8. $G^E$-Models: Hildebrand-model, Flory-Huggins-model, Wilson-model, UNIQUAC, UNIFAC<br>9. Liquid-liquid-equilibria: equilibrium condition, phase equilibria in binary and ternary systems<br>10. Solid-liquid-equilibria: equilibrium condition, binary systems<br>11. Chemical reactions: reaction coordinate, mass action law, influence of pressure and temperature<br>12. Osmotic pressure<br><br>The students work on tasks in small groups and present their results in front of all students. |
| **Literature** | • Jürgen Gmehling, Bärbel Kolbe: Thermodynamik. VCH 1992<br>• J.M. Prausnitz, R.N. Lichtenthaler, E.G. de Azevedo: Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed. Prentice Hall, 1999.<br>• J.W. Tester, M. Modell: Thermodynamics and its Applications. 3rd ed. Prentice Hall, 1997.J.P. O´Connell, J.M. Haile: Thermodynamics. Cambridge University Press, 2005. |

| Course L0142: Phase Equilibria Thermodynamics | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction: Applications of thermodynamics of mixtures<br>2. Thermodynamic equations in multi-component systems: Fundamental equations, chemical potential, fugacity<br>3. Phase equilibria of pure substances: thermodynamic equilibrium, vapor pressure, Gibbs' phase rule<br>4. Equations of state: virial equations, van-der-Waals equation, generalized equations of state<br>5. Mixing properties: ideal and real mixtures, excess properties, partial molar properties<br>6. Vapor-liquid-equilibria: binary systems, azeotropes, equilibrium condition<br>7. Gas-liquid-equilibria: equilibrium condition, Henry-coefficient<br>8. $G^E$-Models: Hildebrand-model, Flory-Huggins-model, Wilson-model, UNIQUAC, UNIFAC<br>9. Liquid-liquid-equilibria: equilibrium condition, phase equilibria in binary and ternary systems<br>10. Solid-liquid-equilibria: equilibrium condition, binary systems<br>11. Chemical reactions: reaction coordinate, mass action law, influence of pressure and temperature<br>12. Osmotic pressure |
| **Literature** | • Jürgen Gmehling, Bärbel Kolbe: Thermodynamik. VCH 1992<br>• J.M. Prausnitz, R.N. Lichtenthaler, E.G. de Azevedo: Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed. Prentice Hall, 1999.<br>• J.W. Tester, M. Modell: Thermodynamics and its Applications. 3rd ed. Prentice Hall, 1997.J.P. O´Connell, J.M. Haile: Thermodynamics. Cambridge University Press, 2005. |

## Module M0877: Fundamentals in Molecular Biology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Genetics and Molecular Biology (L0889) | Project-/problem-based Learning | 1 | 1 |
| Genetics and Molecular Biology (L0886) | Lecture | 2 | 2 |
| Molecular Biology Lab Course (L0890) | Practical Course | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Johannes Gescher |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Lecture Biochemistry<br>Lecture Microbiology |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After successfully finishing this module students are able<br>• to give an overview of the basic genetic processes in the cell<br>• to explain basic molecularbiological methods<br>• to give an overview of -omics strategies<br>• to explain genetic differences between pro- and eukaryotes |
| *Skills* | Students are able to<br>• consider safety measurements when working in the laboratory<br>• work sterile<br>• cultivate microorganisms aerobically<br>• measure enzyme activity<br>• identify microorganisms based and physiological assays and 16S rRNA encoding gene sequences<br>• apply core knowledge of the lectures "Biochemistry" and "Microbiology" in laboratory experiments<br>• scientific poster design and presentation |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• conduct laboratory experiments in teams<br>• write protocols in teams<br>• develop solutions for given problems<br>• develop and distribute work assignments for given problems<br>• present and reflect their specific knowledge in discussions with fellow students and tutors<br>• present and discuss their own scientific poster |
| *Autonomy* | Students are able to<br>• search information for a given problem by themselves<br>• prepare summaries of their search results for the team |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: Yes; Bonus: 20 %; Form: Subject theoretical and practical work; Description: Erstellung und Präsentation eines wissenschaftlichen Posters |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering, Focus Bio Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory |

### Course L0889: Genetics and Molecular Biology

| | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Johannes Gescher |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0886: Genetics and Molecular Biology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Johannes Gescher |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | - Organisation, structure and function of procaryotic DNA<br>- DNA replication, transcription, translation<br>- Regulation of gene expression<br>- Mechanisms of gene transfer, recombination, transposition<br>- Mutatuion and DNA repair<br>- DNA cloning<br>- DNA sequencing<br>- Polymerase chain reaction<br>- Genome sequencing, (meta)genomics, transcriptomics, proteomics |
| **Literature** | Rolf Knippers, **Molekulare Genetik**, Georg Thieme Verlag Stuttgart<br>Munk, K. (ed.), **Genetik**, 2010, Thieme Verlag<br>John Ringo, **Genetik kompakt**, 2006, Elsevier GmbH, München<br>T. A. Brown, **Gene und Genome**, 2007, 3. Aufl., Spektrum Akademischer Verlag,<br>Jochen Graw, **Genetik,** Springer Verlag, Berlin Heidelberg |

| Course L0890: Molecular Biology Lab Course | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Johannes Gescher |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Widespread techniques of microbiological, biochemical and genetic approaches will be taught during this course.<br>Before the practical conduct of the experiments a colloquium takes place in which the students explain, reflect and discuss the theoretical basics and their translation into practice.<br>The students write up a report for every experiment. They receive feedback to their level of scientific writing (citation methods, labeling of graphs, etc.), so that they can improve their competence in this field over the course of the practical course.<br>Topics and Methods of the course include:<br>- Morphology and growth of different bacteria strains<br>- Measuring of microbial growth by turbidity<br>- Preparation of several culture media<br>- Strain identification by gram staining and analytical profile index (API test)<br>- Genetic background identification by 16S rRNA analysis<br>- Microscopy<br>- BLAST analyses<br>- Colony PCR procedure<br>- Enzyme activity measurements and kinetics (Michaelis-Menten equation, Lineweaver-Burk plot)<br>- Enzymes as biocatalysts (exemplarily use of enzymes in detergents)<br>- Measurement of protein concentrations (Bradford protein assay)<br>- Qualitative and quantitative enzyme activity assay |
| **Literature** | Brock Mikrobiologie / Brock Microbiology (Michael T. Madigan, John M. Martinko)<br>Mikrobiologisches Grundpraktikum (Steve K. Alexander, Dennis Strete) |

## Module M1769: Regulatory aspects of biological agents

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Regulatory aspects of biological agents (L2865) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Anna-Lena Heins |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | 1. Experience in the general operation of industrial chemical and bioprocesses<br>2. Knowledge of biological relationships and substance groups<br>3. Experience with the handling of hazardous substances, which has been acquired in laboratory experiments |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After successfully participating in the course "Regulatory Aspects of Biological Agents", students can<br>- explain the legal framework for biotechnological and chemical work,<br>- Illustrate excerpts from e.g. the Act on the Implementation of Measures of Occupational Safety and Health, Biological Agents Ordinance, Infection Protection Act, German Chemicals Act, Hazardous Substances Ordinance, Genetic Engineering Act Stem Cell Act, and Embryo Protection Act,<br>- Assign genetic engineering work and equipment in biotechnological genetic laboratories according to the security level,<br>- Assign current Good Manufacturing Practice (cGMP) with reference to the EU-GMP guidelines as well as international regulations and guidelines for biopharmaceuticals (ICH guidelines). |
| *Skills* | Students will be able to evaluate biotechnological work with not modified and genetically modified organisms based on the legal framework. |
| **Personal Competence** | |
| *Social Competence* | Students are prepared for the independent assessment of legal issues, especially in the biotechnological field. |
| *Autonomy* | Students will be able to responsibly align and perform their own work with knowledge of the legal situation and assist colleagues in assessing the legal situation. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory |

### Course L2865: Regulatory aspects of biological agents

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Johannes Möller |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | This lecture deals with the legal framework of biotechnological and chemical work. On the basis of the acts and ordinacesto be considered (e.g. Occupational Health and Safety Act, Biological Substances Ordinance, Genetic Engineering Act, etc.), the legal frameworks are explained. In addition, requirements for safety classifications of genetic engineering work and the equipment of laboratories for genetic engineering work genetic are presented. Furthermore, national and international requirements for drug production with industrial reference are discussed. |
| **Literature** | Die zum Zeitpunkt der Vorlesung gültigen Gesetze werden in der Vorlesung dargestellt und bekanntgegeben. |

## Module M1770: Bioinformatics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Bioinformatics (L2899) | Seminar | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Johannes Gescher |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Students should be familiar with the basics of molecular biology and genetics, and have knowledge of microbial cultivation.<br><br>In addition, prior knowledge of DNA sequencing technologies and the phylogenetic tree of life is advantageous. Also helpful is some experience with command line based computer input. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | During the course, students gain knowledge of different application areas of DNA sequencing technologies, the potential in previously uncharacterized microbial metabolic pathways, how life forms differ in the metabolism of microbes, and the benefits in the growth of microbial communities. |
| *Skills* | By the end of the seminar, participants will be familiar with the basics of command line usage and the difficulties of dealing with large data sets. Specifically, applications for analyzing sequencing data will be practiced, as well as interpretation for characterizing microbial systems.<br><br>Topics covered in the course:<br><br>- Genome sequencing on a MinION<br><br>- De novo genome assembly<br><br>- Metagenome analyses<br><br>- Functional and taxonomic annotation of gene sequences<br><br>- Construction of phylogenetic trees<br><br>- Representation of metabolic pathways<br><br>- Genome mining<br><br>- Protein structure analyses |
| **Personal Competence** | |
| *Social Competence* | Tasks are worked on in groups. Whereby a clear presentation of the used parameters, methods and intermediate results must be chosen for communication in the group. |
| *Autonomy* | Students will be able to summarize their findings from the completed subtasks in a report. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Presentation and colloqium |
| **Assignment for the Following Curricula** | Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering, Focus Bio Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory |

### Course L2899: Bioinformatics

| | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Johannes Gescher |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Methods to assess DNA sequencingdata, including:<br><br>• Genome sequencing on a MinION<br>• De novo genome assembly<br>• Metagenome analyses<br>• Functional and taxonomic annotation of gene sequences<br>• Construction of phylogenetic trees<br>• Representation of metabolic pathways<br>• Genome mining<br>• Protein structure analyses |
| **Literature** | Relevante Literatur wird im Kurs zur Verfügung gestellt. |

## Specialization Energy Systems / Renewable Energies

The specialisation "Energy Systems" aims to provide students with an in-depth understanding of the fundamental content in (regenerative) energy systems; this also applies to future-oriented (energy) technologies. The focus is on the interactions of new processes of climate-friendly energy supply and integration of renewable energies with the fundamentals of process, energy and environmental technology. In this specialisation, students acquire competences in the area of "green" technologies as part of a future-oriented and thus sustainable energy system.

### Module M1693: Computer Science for Engineers - Programming Concepts, Data Handling & Communication

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Computer Science for Engineers - Programming Concepts, Data Handling & Communication (L2689) | Lecture | 3 | 3 |
| Computer Science for Engineers - Programming Concepts, Data Handling & Communication (L2690) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Sibylle Fröschle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence**<br>*Knowledge*<br>*Skills*<br>**Personal Competence**<br>*Social Competence*<br>*Autonomy* | |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: No; Bonus: 10 %; Form: Attestation; Description: Testate finden semesterbegleitend statt. |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Logistics and Mobility: Specialisation Information Technology: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Elective Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Compulsory |

### Course L2689: Computer Science for Engineers - Programming Concepts, Data Handling & Communication

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Sibylle Fröschle |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | John V. Guttag: Introduction to Computation and Programming Using Python.<br>With Application to Understanding Data. 2nd Edition. The MIT Press, 2016. |

| Course L2690: Computer Science for Engineers - Programming Concepts, Data Handling & Communication | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sibylle Fröschle |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0546: Thermal Separation Processes

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Thermal Separation Processes (L0118) | Lecture | 2 | 2 |
| Thermal Separation Processes (L0119) | Recitation Section (small) | 2 | 2 |
| Thermal Separation Processes (L0141) | Recitation Section (large) | 1 | 1 |
| Separation Processes (L1159) | Practical Course | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Irina Smirnova |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Recommended requirements: Thermodynamics III |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • The students can distinguish and describe different types of separation processes such as distillation, extraction, and adsorption<br>• The students develop an understanding for the course of concentration during a separation process, the estimation of the energy demand of a process, the possibilities of energy saving, and the selection of separation systems<br>• They have good knowledge of designing methods for separation processes and devices |
| *Skills* | • Using the gained knowledge the students can select a reasonable system boundary for a given separation process and can close the associated energy and material balances<br>• The students can use different graphical methods for the designing of a separation process and define the amount of theoretical stages required<br>• They can select and design a basic type of thermal separation process for a given case based on the advantages and disadvantages of the process<br>• The students are capable to obtain independently the needed material properties from appropriate sources (diagrams and tables)<br>• They can calculate continuous and discontinuous processes<br>• The students are able to prove their theoretical knowledge in the experimental lab work.<br>• The students are able to discuss the theoretical background and the content of the experimental work with the teachers in colloquium.<br><br>The students are capable of linking their gained knowledge with the content of other lectures and use it together for the solution of technical problems. Other lectures such as thermodynamics, fluid mechanics and chemical engineering. |
| **Personal Competence** | |
| *Social Competence* | • The students can work technical assignments in small groups and present the combined results in the tutorial<br><br>• The students are able to carry out practical lab work in small groups and organize a functional division of labor between them. They are able to discuss their results and to document them scientifically in a report. |
| *Autonomy* | • The students are capable to obtain the needed information from suitable sources by themselves and assess their quality<br>• The students can proof the state of their knowledge with exam resembling assignments and in this way control their learning process |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes; theoretical questions and calculations |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0118: Thermal Separation Processes | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction in the thermal process engineering and to the main features of separation processes<br>• Simple equilibrium processes, several steps processes<br>• Distillation of binary mixtures, enthalpy-concentration diagrams<br>• Extractive and azeotrope distillation, water vapor distillation, stepwise distillation<br>• Extraction: separation ternary systems, ternary diagram<br>• Multiphase separation including complex mixtures<br>• Designing of separation devices without discrete stages<br>• Drying<br>• Chromatographic separation processes<br>• Membrane separation<br>• Energy demand of separation processes<br>• Advance overview of separation processes<br>• Selection of separation processes |
| **Literature** | • G. Brunner: Skriptum Thermische Verfahrenstechnik<br>• J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980<br>• Sattler: Thermische Trennverfahren, VCH, Weinheim 1995<br>• J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998.<br>• Mersmann: Thermische Verfahrenstechnik, Springer, 1980<br>• Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997<br>• Brunner, G.: Gas extraction. An introduction to fundamentals of supercritical fluids and the application to separation processes. Steinkopff, Darmstadt; Springer, New York; 1994. ISBN 3-7985-0944-1 ; ISBN 0-387-91477-3 .<br>• R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006.<br>◦ Perry"s Chemical Engineers" Handbook, R.H. Perry, D.W. Green, J.O. Maloney (Hrsg.), 6th ed., McGraw-Hill, New York 1984 Ullmann"s Enzyklopädie der Technischen Chemie |

| **Course L0119: Thermal Separation Processes** | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction in the thermal process engineering and to the main features of separation processes<br>• Simple equilibrium processes, several steps processes<br>• Distillation of binary mixtures, enthalpy-concentration diagrams<br>• Extractive and azeotrope distillation, water vapor distillation, stepwise distillation<br>• Extraction: separation ternary systems, ternary diagram<br>• Multiphase separation including complex mixtures<br>• Designing of separation devices without discrete stages<br>• Drying<br>• Chromatographic separation processes<br>• Membrane separation<br>• Energy demand of separation processes<br>• Advance overview of separation processes<br>• Selection of separation processes<br><br>The students work on tasks in small groups and present their results in front of all students. |
| **Literature** | • G. Brunner: Skriptum Thermische Verfahrenstechnik<br>• J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980<br>• Sattler: Thermische Trennverfahren, VCH, Weinheim 1995<br>• J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998.<br>• Mersmann: Thermische Verfahrenstechnik, Springer, 1980<br>• Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997<br>• Brunner, G.: Gas extraction. An introduction to fundamentals of supercritical fluids and the application to separation processes. Steinkopff, Darmstadt; Springer, New York; 1994. ISBN 3-7985-0944-1 ; ISBN 0-387-91477-3 .<br>• R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006.<br>• Perry"s Chemical Engineers" Handbook, R.H. Perry, D.W. Green, J.O. Maloney (Hrsg.), 6th ed., McGraw-Hill, New York 1984 Ullmann"s Enzyklopädie der Technischen Chemie |

| Course L0141: Thermal Separation Processes | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction in the thermal process engineering and to the main features of separation processes<br>• Simple equilibrium processes, several steps processes<br>• Distillation of binary mixtures, enthalpy-concentration diagrams<br>• Extractive and azeotrope distillation, water vapor distillation, stepwise distillation<br>• Extraction: separation ternary systems, ternary diagram<br>• Multiphase separation including complex mixtures<br>• Designing of separation devices without discrete stages<br>• Drying<br>• Chromatographic separation processes<br>• Membrane separation<br>• Energy demand of separation processes<br>• Advance overview of separation processes<br>• Selection of separation processes |
| **Literature** | • G. Brunner: Skriptum Thermische Verfahrenstechnik<br>• J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980<br>• Sattler: Thermische Trennverfahren, VCH, Weinheim 1995<br>• J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998.<br>• Mersmann: Thermische Verfahrenstechnik, Springer, 1980<br>• Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997<br>• Brunner, G.: Gas extraction. An introduction to fundamentals of supercritical fluids and the application to separation processes. Steinkopff, Darmstadt; Springer, New York; 1994. ISBN 3-7985-0944-1 ; ISBN 0-387-91477-3 .<br>• R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006.<br>• Perry"s Chemical Engineers" Handbook, R.H. Perry, D.W. Green, J.O. Maloney (Hrsg.), 6th ed., McGraw-Hill, New York 1984 Ullmann"s Enzyklopädie der Technischen Chemie |

| Course L1159: Separation Processes | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | The students work on eight different experiments in this practical course. For every one of the eight experiments, a colloquium takes place in which the students explain and discuss the theoretical background and its translation into practice with staff and fellow students.<br><br>The students work small groups with a high degree of division of labor. For every experiment, the students write a report. They receive instructions in terms of scientific writing as well as feedback on their own reports and level of scientific writing so they can increase their capabilities in this area.<br><br>Topics of the practical course:<br><br>• Introduction in the thermal process engineering and to the main features of separation processes<br>• Simple equilibrium processes, several steps processes<br>• Distillation of binary mixtures, enthalpy-concentration diagrams<br>• Extractive and azeotrope distillation, water vapor distillation, stepwise distillation<br>• Extraction: separation ternary systems, ternary diagram<br>• Multiphase separation including complex mixtures<br>• Designing of separation devices without discrete stages<br>• Drying<br>• Chromatographic separation processes<br>• Membrane separation<br>• Energy demand of separation processes<br>• Advance overview of separation processes<br>• Selection of separation processes |
| **Literature** | • G. Brunner: Skriptum Thermische Verfahrenstechnik<br>• J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980<br>• Sattler: Thermische Trennverfahren, VCH, Weinheim 1995<br>• J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998.<br>• Mersmann: Thermische Verfahrenstechnik, Springer, 1980<br>• Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997<br>• Brunner, G.: Gas extraction. An introduction to fundamentals of supercritical fluids and the application to separation processes. Steinkopff, Darmstadt; Springer, New York; 1994. ISBN 3-7985-0944-1 ; ISBN 0-387-91477-3 .<br>• R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006.<br>• Perry"s Chemical Engineers" Handbook, R.H. Perry, D.W. Green, J.O. Maloney (Hrsg.), 6th ed., McGraw-Hill, New York 1984 Ullmann"s Enzyklopädie der Technischen Chemie |

## Module M1235: Electrical Power Systems I: Introduction to Electrical Power Systems

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Electrical Power Systems I: Introduction to Electrical Power Systems (L1670) | Lecture | 3 | 4 |
| Electrical Power Systems I: Introduction to Electrical Power Systems (L1671) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Christian Becker |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of Electrical Engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to give an overview of conventional and modern electric power systems. They can explain in detail and critically evaluate technologies of electric power generation, transmission, storage, and distribution as well as integration of equipment into electric power systems. |
| *Skills* | With completion of this module the students are able to apply the acquired skills in applications of the design, integration, development of electric power systems and to assess the results. |
| **Personal Competence** | |
| *Social Competence* | The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own work results in front of others. |
| *Autonomy* | Students can independently tap knowledge of the emphasis of the lectures. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 - 150 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>Engineering Science: Specialisation Electrical Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory |

| Course L1670: Electrical Power Systems I: Introduction to Electrical Power Systems | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Christian Becker |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • fundamentals and current development trends in electric power engineering<br>• tasks and history of electric power systems<br>• symmetric three-phase systems<br>• fundamentals and modelling of eletric power systems<br>  ◦ lines<br>  ◦ transformers<br>  ◦ synchronous machines<br>  ◦ induction machines<br>  ◦ loads and compensation<br>  ◦ grid structures and substations<br>• fundamentals of energy conversion<br>  ◦ electro-mechanical energy conversion<br>  ◦ thermodynamics<br>  ◦ power station technology<br>  ◦ renewable energy conversion systems<br>• steady-state network calculation<br>  ◦ network modelling<br>  ◦ load flow calculation<br>  ◦ (n-1)-criterion<br>• symmetric failure calculations, short-circuit power<br>• control in networks and power stations<br>• grid protection<br>• grid planning |
| **Literature** | K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Springer Vieweg, 9. Auflage, 2013<br><br>A. J. Schwab: "Elektroenergiesysteme", Springer, 7. Auflage, 2022<br><br>R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008 |

| Course L1671: Electrical Power Systems I: Introduction to Electrical Power Systems | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Becker |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • fundamentals and current development trends in electric power engineering<br>• tasks and history of electric power systems<br>• symmetric three-phase systems<br>• fundamentals and modelling of eletric power systems<br>  ◦ lines<br>  ◦ transformers<br>  ◦ synchronous machines<br>  ◦ induction machines<br>  ◦ loads and compensation<br>  ◦ grid structures and substations<br>• fundamentals of energy conversion<br>  ◦ electro-mechanical energy conversion<br>  ◦ thermodynamics<br>  ◦ power station technology<br>  ◦ renewable energy conversion systems<br>• steady-state network calculation<br>  ◦ network modelling<br>  ◦ load flow calculation<br>  ◦ (n-1)-criterion<br>• symmetric failure calculations, short-circuit power<br>• control in networks and power stations<br>• grid protection<br>• grid planning<br>• power economy fundamentals |
| **Literature** | K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Springer Vieweg, 9. Auflage, 2013<br><br>A. J. Schwab: "Elektroenergiesysteme", Springer, 7. Auflage, 2022<br><br>R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008 |

## Module M1713: Green Technologies III

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Study Work Green Technologies (L2766) | Project Seminar | 2 | 4 |
| Scientific Work and Writing (L2765) | Seminar | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Dozenten des Studiengangs |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | keine |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students, based on a literature survey, learn to study in detail a subject theme from the disciplines of green technologies and deliver afterwards a summary presentation to a specialised audience. Environmental issues and their multidisciplinary linkages are preferred, when selecting the thematic area of these studies. Through their own written contribution the students communicate an overview over the subject and practice technical writing. With the discussion the students practice scientific debating on a specialised subject matter. |
| *Skills* | The students can, when working on a technical topic not familiar to them:<br>• conduct a literature survey<br>• choose the relevant information for their presentation<br>• prepare a written summary<br>• present results in front of peers and staff<br>• correctly cite and reference sources. |
| **Personal Competence** | |
| *Social Competence* | The students practice a critical assessment of the literature in a predefined specialised theme and learn to give presentations on their own technical sub-topic tailored to their public and discuss with the audience. When attending technical presentations, the students can formulate questions to other speakers and participate in the ensuing discussion.<br>The fulfilment of the tasks combines independent work with group and teamwork. |
| *Autonomy* | The students can, guided by instructors, critically reflect on their learning and work status, and write a scientific report. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Study work |
| **Examination duration and scale** | - |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory |

### Course L2766: Study Work Green Technologies

| | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Studiengangs |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Students carry out a research project in a scientific field under the guidance of an academic staff member. For this purpose, the student can approach the staff of the respective institute and discuss a topic. The topic is then worked on within 4 weeks and regular consultations are held with the supervisor. The student research project should be the size of a scientific article and must be presented to the lecturer after completion as part of a presentation (approx. 15 minutes). |
| **Literature** | |

| Course L2765: Scientific Work and Writing | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Studiengangs, Dr. Detlev Bieler, Florian Hagen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The seminar offers an introduction into the diverse aspects of academic research and writing: Finding the topic, finding specialized information, knowledge organisation, writing, presenting and publishing. Suggestions for reflecting own processes of learning, informing and writing - in addition to practical recommendations and tips - facilitate the start and the creation of bachelor and master theses, works, which bring thoroughly self-fulfillment and make fun.<br><br>Topics of the seminar will be in particular<br><br>• Scientific scholarship and academic research methods:<br>• Introduction, organization, attributes of science:<br>How is scientific knowledge created?<br>Work scheduling, finding topics, time management, specialities of academic research in engineering<br>• Finding specialized information: Full texts and library resources, databases http://www.tub.tuhh.de/en/subject-information/informing-points-to-survive/<br>• Reference management: http://www.tub.tuhh.de/en/publishing/reference-management/<br>Knowledge organisation and creating publications with Citavi<br>• Citing correctly and avoiding plagiarism<br>• Preparing and doing presentations |
| **Literature** | 1. Semesterapparat "Wissenschaftliches Arbeiten" in der TU-Bibliothek: http://tinyurl.com/Semesterapparat-Wiss-Arbeiten<br>2. Weblog Wissenschaftliches Arbeiten der TU-Bibliothek: https://www.tub.tuhh.de/wissenschaftliches-arbeiten/<br>3. Online-Tutorial VISION der TU-Bibliothek zum wissenschaftlichen Arbeiten: https://www.vision.tuhh.de (funktioniert nur mit installiertem Flash)<br>4. Andreas Hirsch-Weber, Stefan Scherer: Wissenschaftliches Arbeiten und Abschlussarbeit in Natur- und Ingenieurwissenschaften : Grundlagen, Praxisbeispiele, Übungen. Stuttgart: Ulmer, 2016.<br>5. Werner Sesink: Einführung in das wissenschaftliche Arbeiten : inklusive E-Learning, Web-Recherche, digitale Präsentation u.a. 9., aktualisierte Aufl. München : Oldenbourg, 2012.<br>6. Judith Theuerkauf: Schreiben im Ingenieurstudium : effektiv und effizient zur Bachelor-, Master- und Doktorarbeit. Paderborn : Schöningh, 2012.<br>7. Wolfsberger, Judith: Frei geschrieben : Mut, Freiheit & Strategie für wissenschaftliche Abschlussarbeiten. Wien: Böhlau, 2010<br>8. Biedermann, Wieland u.a.: Forschungsmethodik in den Ingenieurwissenschaften : Skript vom Lehrstuhl für Produktentwicklung, Prof. Dr.-Ing. Udo Lindemann, Technische Universität München (TUM), 2012. https://www.mw.tum.de/fileadmin/w00btx/lpl/Documents/Forschungsmethodik_Skript.pdf<br>9. Wissenschaftliches Arbeiten - HOOU Angebot der HCU Hamburg: https://blogs.hoou.de/wissarbeiten/<br><br>1. Course Reserves Collection "Scholarly Research Methods" in the TUHH library: http://tinyurl.com/Semesterapparat-Wiss-Arbeiten<br>2. Scholarly research methods via TUHH library Website: https://www.tub.tuhh.de/en/scholarly-research-methods/<br>3. VISION - Online-Tutorial on research methods by the TUHH library: http://www.vision.tuhh.de (Flash has to be installed)<br>4. Scientific papers and presentations / Martha Davis. 3. ed. Amsterdam: Elsevier / Academic Press, 2013. http://www.sciencedirect.com/science/book/9780123847270<br>5. Writing for science and engineering : papers, presentations and reports / Heather Silyn-Roberts. 2nd ed. Amsterdam : Elsevier, 2013. http://www.sciencedirect.com/science/book/9780080982854<br>6. How to research / Loraine Blaxter, Christina Hughes and Malcolm Tight. Maidenhead : Open Univ. Press, 2010.<br>7. Managing information for research : practical help in researching, writing and designing dissertations / Elizabeth Orna and Graham Stevens. Maidenhead : Open University Press McGraw-Hill, 2009.<br>8. Writing scientific research articles : strategy and steps / Margaret Cargill and Patrick O'Connor. Chichester : Wiley-Blackwell, 2009. |

## Module M1726: System Integration Renewable Energies

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| System Integration Renewable Energies I (L2767) | Lecture | 2 | 2 |
| System Integration Renewable Energies I (L2768) | Recitation Section (small) | 1 | 1 |
| System Integration Renewable Energies II (L2769) | Lecture | 2 | 2 |
| System Integration Renewable Energies II (L2770) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of renewable energies and the energy system |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | With the completion of the module the students are able to use and apply the previously learned technical basics of the different fields of renewable energies. Current problems concerning the integration of renewable energies in the energy system are presented and analyzed. In particular, the sectors electricity, heat and mobility will be addressed, giving students insights into sector coupling activities. |
| *Skills* | By completing this module, students can apply the basics learned to various sector coupling problems and, in this context, assess the potentials as well as the limits of sector coupling in the German energy system. In particular, the students should use the application and linking of already learned methods and knowledge here, so that a vision of the different technologies is achieved. |
| **Personal Competence** | |
| *Social Competence* | The students will be able to discuss problems in the areas of sector coupling and the integration of renewable energies. |
| *Autonomy* | The students are able to acquire own sources based on the main topics of the lecture and to increase their knowledge. Furthermore, the students can search further technologies and interconnection possibilities for the energy system itself. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory |

| Course L2767: System Integration Renewable Energies I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Volker Lenz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 1. Introduction<br>2. Fossil-dominated energy system<br>3. Mega trends in energy transition<br>4. Characteristics of renewable energy provision technologies - electricity<br>5. Integration of renewables - electricity I<br>6. Integration of renewables - electricity II<br>7. Characteristics of renewable energy provision technologies - heat<br>8. Integration of renewables - heat I<br>9. Integration of renewables - heat II<br>10. Characteristics of renewable energy provision technologies - mobility<br>11. Integration of renewables - mobility<br>12. Communications technology and control engineering<br>13. Reduction in consumption<br>14. Load management<br>15. Interaction of renewable generation and controlled reduction in demand |
| **Literature** | • D. Thrän (editor): Smart Bioenergy. Technologies and concepts for a more flexible bioenergy provision in future energy systems. Springer,Cham, Heielberg, New York, Dordrecht, London, 2015<br>• R. von Miller (Hrsg.): Lexikon der Energietechnik und Kraftmaschinen Band 6 und 7. Deutsche Verlags-Anstalt Stuttgart 1965<br>• K. Naumann et. al.: Monitoring Biokraftstoffsektor. 3. Auflage, DBFZ Report Nr. 1, Leipzig, 2016<br>• M. Kaltschmitt, W. Streicher, A. Wiese (Hrsg.): Erneuerbare Energien. Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. 4. Auflage, Springer |

| Course L2768: System Integration Renewable Energies I | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Volker Lenz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L2769: System Integration Renewable Energies II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Volker Lenz |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction<br>2. Power-to-Hydrogen<br>3. Power-to-Gas<br>4. Power-to-Liquid<br>5. Power-to-Heat<br>6. Hybrid Technologies<br>7. Combined Technology Concepts I<br>8. Combined Technology Concepts II<br>9. Link-up with renewable industrial production<br>10. Utilization of residual materials from renewable energy provision<br>11. Biomass as system stabilizer I<br>12. Biomass as system stabilizer II<br>13. System modelling - fundamentals<br>14. System modelling - approaches and results<br>15. Planning tools |
| **Literature** | • D. Thrän (editor): Smart Bioenergy. Technologies and concepts for a more flexible bioenergy provision in future energy systems. Springer,Cham, Heielberg, New York, Dordrecht, London, 2015<br>• R. von Miller (Hrsg.): Lexikon der Energietechnik und Kraftmaschinen Band 6 und 7. Deutsche Verlags-Anstalt Stuttgart 1965<br>• K. Naumann et. al.: Monitoring Biokraftstoffsektor. 3. Auflage, DBFZ Report Nr. 1, Leipzig, 2016<br>• M. Kaltschmitt, W. Streicher, A. Wiese (Hrsg.): Erneuerbare Energien. Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. 4. Auflage, Springer Berlin Heidelberg, 2006<br>• Bundesministerium für Wirtschaft und Energie: Die Energie der Zukunft. |

| Course L2770: System Integration Renewable Energies II | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Volker Lenz |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction<br>2. Power-to-Hydrogen<br>3. Power-to-Gas<br>4. Power-to-Liquid<br>5. Power-to-Heat<br>6. Hybrid Technologies<br>7. Combined Technology Concepts I<br>8. Combined Technology Concepts II<br>9. Link-up with renewable industrial production<br>10. Utilization of residual materials from renewable energy provision<br>11. Biomass as system stabilizer I<br>12. Biomass as system stabilizer II<br>13. System modelling - fundamentals<br>14. System modelling - approaches and results<br>15. Planning tools |
| **Literature** | • D. Thrän (editor): Smart Bioenergy. Technologies and concepts for a more flexible bioenergy provision in future energy systems. Springer,Cham, Heielberg, New York, Dordrecht, London, 2015<br>• R. von Miller (Hrsg.): Lexikon der Energietechnik und Kraftmaschinen Band 6 und 7. Deutsche Verlags-Anstalt Stuttgart 1965<br>• K. Naumann et. al.: Monitoring Biokraftstoffsektor. 3. Auflage, DBFZ Report Nr. 1, Leipzig, 2016<br>• M. Kaltschmitt, W. Streicher, A. Wiese (Hrsg.): Erneuerbare Energien. Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. 4. Auflage, Springer Berlin Heidelberg, 2006<br>• Bundesministerium für Wirtschaft und Energie: Die Energie der Zukunft. |

## Module M1719: Climate change impact & mitigation

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Basics of climate change and its effects (L2749) | Lecture | 2 | 2 |
| Technical measures to mitigate greenhouse gas emissions (L2747) | Lecture | 2 | 2 |
| Technical measures to mitigate greenhouse gas emissions (L2748) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Alexander Penn |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Upon completion of the module, students will be able to use and apply the previously learned technical basics of the various fields of metereological climate change and technical climate protection in an interdisciplinary manner. Current problems are presented and analyzed in relation to solutions for the mitigation of climate change and the impact of human behavior on the climate is described and discussed. |
| *Skills* | Upon completion of this module, students will be able to apply the fundamentals they have learned to various cross-sectoral problems and, in this context, assess and evaluate the potentials but also the limitations of technical solutions for reducing greenhouse gas emissions and their impact on climate change. In particular, the application and linking of already learned methods and knowledge should be applied by the students here, so that a broad view of the different technologies is gained. |
| **Personal Competence** | |
| *Social Competence* | Students will be able to discuss problems in the topic areas of reducing impacts and changing the climate with each other. |
| *Autonomy* | Students will be able to independently access sources and acquire knowledge based on the lecture focus on the subject area. Furthermore, students will be able to research further climate change mitigation technologies and climate conditions on their own. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory |

### Course L2749: Basics of climate change and its effects

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jana Sillmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | **Course Content:**<br><br>This course provides a comprehensive introduction to the fundamentals of human-induced climate change. Important concepts such as the Earth's radiation budget, the greenhouse effect, and the various Earth system components (e.g., atmosphere, hydrosphere, cryosphere, biosphere) related to climate change are explained. Fundamentals of climate modeling and climate scenarios are explained. Findings from the Intergovernmental Panel on Climate Change's Assessment Reports are provided in relation to observed and model-based physical climate changes and their impacts on various Earth system components. Furthermore, the impacts of global and regional climate change on society (e.g. agriculture, infrastructure, energy) will be highlighted and especially the changes and impacts of weather and climate extremes will be discussed. In the last part of the lecture, current global and national climate change targets will be explained and discussed in the context of possible scenarios, options and challenges to reduce global warming. Concepts such as "net-zero" emissions and negative emissions will be addressed with important implications for the development of new technologies.<br><br>**Learning Objective:**<br><br>Basic knowledge of human-induced climate change, and how to model climate change, and its impacts on different sectors of the environment and society, and the options and consequences for different sectors to achieve the targeted climate goals (reduction of global warming).<br><br>**Structure:**<br><br>Introduction Climate Change/Climate Change Reports.<br><br>The climate system<br><br>Observed climate change<br><br>Climate variability<br><br>Climate models |

| | |
|---|---|
| | Climate scenarios<br>Physical climate changes under different scenarios<br>Impacts of climate change on different regions and sectors<br>Weather and climate extremes<br>Climate risk and adaptation<br>Scenarios, options and challenges to reduce global warming<br>Climate Engineering<br>Sustainability and climate change<br>Climate quiz and discussion<br>**Course Content:**<br>This course provides a comprehensive introduction to the fundamentals of human-induced climate change. Important concepts such as the Earth's radiation budget, the greenhouse effect, and the various Earth system components (e.g., atmosphere, hydrosphere, cryosphere, biosphere) related to climate change are explained. Fundamentals of climate modeling and climate scenarios are explained. Findings from the Intergovernmental Panel on Climate Change's Assessment Reports are provided in relation to observed and model-based physical climate changes and their impacts on various Earth system components. Furthermore, the impacts of global and regional climate change on society (e.g. agriculture, infrastructure, energy) will be highlighted and especially the changes and impacts of weather and climate extremes will be discussed. In the last part of the lecture, current global and national climate change targets will be explained and discussed in the context of possible scenarios, options and challenges to reduce global warming. Concepts such as "net-zero" emissions and negative emissions will be addressed with important implications for the development of new technologies.<br>**Learning Objective:**<br>Basic knowledge of human-induced climate change, and how to model climate change, and its impacts on different sectors of the environment and society, and the options and consequences for different sectors to achieve the targeted climate goals (reduction of global warming).<br>**Structure:**<br>Introduction Climate Change/Climate Change Reports.<br>The climate system<br>Observed climate change<br>Climate variability<br>Climate models<br>Climate scenarios<br>Physical climate changes under different scenarios<br>Impacts of climate change on different regions and sectors<br>Weather and climate extremes<br>Climate risk and adaptation<br>Scenarios, options and challenges to reduce global warming<br>Climate Engineering<br>Sustainability and climate change<br>Climate quiz and discussion |
| **Literature** | Vorlesungsunterlagen |

| Course L2747: Technical measures to mitigate greenhouse gas emissions | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Alexander Penn |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Lecturers: MK, Dr. Ben Norden (GFZ), Dr. Conny Schmidt-Hattenberger (GFZ)<br><br>Lecture Content:<br><br>The goal of this lecture is to address and present technical measures to mitigate climate change. This primarily includes the immediate means by which climate gas emissions can be reduced when they have already occurred. Specifically, the lecture includes the following content:<br><br>- Overview of the main greenhouse gases emitted, including their global warming potential and the average lifetime of the molecules in the atmosphere.<br><br>- Avoidance Methane ($CH_4$) (point sources).<br><br>o Emission sources: Methane slip, methane emission from combustion, etc.<br><br>o Reduction methane slip (including gas extraction, biogas plants, waste management).<br><br>o Reduction of methane from combustion (e.g. power plants, ship engines, car engines, CHP engines, etc.)<br><br>o Reduction of other sources if necessary<br><br>- Avoidance Nitrous oxide ($N_2O$) (point sources).<br><br>o Emission sources: Combustion processes, production processes, biological nitrogen oxidation, etc.<br><br>o Reduction of combustion processes<br><br>o Reduction of production processes<br><br>o Reduction of biological nitrogen oxidation<br><br>o Reduction of further sources, if necessary<br><br>- Avoidance of other greenhouse gases (including F-gases) (point sources)<br><br>- Avoidance of carbon dioxide from fossil carbon (point sources)<br><br>o Emission sources: Combustion processes, production processes<br><br>o Capture technologies from exhaust gases<br><br>- Capture carbon dioxide from diffuse sources (ambient air)<br><br>- Temporary storage and transport of carbon dioxide<br><br>- Final storage of carbon dioxide<br><br>o Geological framework and storage options, infrastructure (assessment)<br><br>o Surface installations / modes of operation / conditioning of $CO_2$ (phase behavior) etc.<br><br>o Thermodynamic framework and interactions<br><br>o Tightness of the storage complex (geomechanics) and long-term behavior (modeling), saltwater displacement and upwelling?<br><br>o Monitoring concepts (monitoring methods from geophysics, geochemistry, microbiology, applied on different spatial and temporal scales) and assessment of storage safety<br><br>o Modeling (static, dynamic, chemical, scale-dependent - borehole, reservoir, energy system modeling).<br><br>o Retrievability (interim storage) and after-use concepts (synthetic fuels)?, backfilling (cements, etc.).<br><br>o Examples |
| **Literature** | Vorlesungsunterlagen |

| Course L2748: Technical measures to mitigate greenhouse gas emissions | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Alexander Penn |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | - Overview of the main greenhouse gases emitted, including their global warming potential and the average lifetime of the molecules in the atmosphere.<br>- Avoidance Methane (CH4) (point sources).<br>o Emission sources: Methane slip, methane emission from combustion, etc.<br>o Reduction methane slip (including gas extraction, biogas plants, waste management).<br>o Reduction of methane from combustion (e.g. power plants, ship engines, car engines, CHP engines, etc.)<br>o Reduction of other sources if necessary<br>- Avoidance Nitrous oxide (N2O) (point sources).<br>o Emission sources: Combustion processes, production processes, biological nitrogen oxidation, etc.<br>o Reduction of combustion processes<br>o Reduction of production processes<br>o Reduction of biological nitrogen oxidation<br>o Reduction of further sources, if necessary<br>- Avoidance of other greenhouse gases (including F-gases) (point sources)<br>- Avoidance of carbon dioxide from fossil carbon (point sources)<br>o Emission sources: Combustion processes, production processes<br>o Capture technologies from exhaust gases<br>- Capture carbon dioxide from diffuse sources (ambient air)<br>- Temporary storage and transport of carbon dioxide<br>- Final storage of carbon dioxide<br>o Geological framework and storage options, infrastructure (assessment)<br>o Surface installations / modes of operation / conditioning of CO2 (phase behavior) etc.<br>o Thermodynamic framework and interactions<br>o Tightness of the storage complex (geomechanics) and long-term behavior (modeling), saltwater displacement and upwelling?<br>o Monitoring concepts (monitoring methods from geophysics, geochemistry, microbiology, applied on different spatial and temporal scales) and assessment of storage safety<br>o Modeling (static, dynamic, chemical, scale-dependent - borehole, reservoir, energy system modeling).<br>o Retrievability (interim storage) and after-use concepts (synthetic fuels)?, backfilling (cements, etc.).<br>o Examples |
| **Literature** | Vorlesungsunterlagen |

## Module M0544: Phase Equilibria Thermodynamics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Phase Equilibria Thermodynamics (L0114) | Lecture | 2 | 2 |
| Phase Equilibria Thermodynamics (L0140) | Recitation Section (small) | 1 | 2 |
| Phase Equilibria Thermodynamics (L0142) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Irina Smirnova |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics, Physical Chemistry, Thermodynamics I and II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Starting from the very basics of thermodynamics, the students learn the mathematical tools to describe thermodynamic equilibria.<br>• They learn how state variables are influenced by the mixing of compounds and learn concepts to quantitatively describe these properties.<br>• Moreover, the students learn how phase equilibria can be described mathematically and which phenomena may occur if different phases (vapor, liquid, solid) coexist in equilibrium. Furthermore the fundamentals of reaction equilibria are taught.<br>• For different phase equilibria, several examples relevant for different kinds of processes are shown and the necessary knowledge for plotting and interpreting the equilibria are taught. |
| *Skills* | • Applying their knowledge, the students are able to identify the correct equation for the determination of the equilibrium state and know how to simplify these equations meaningfully.<br>• The students know models which can be used to determine the properties of the system in the equilibrium state and they are able to solve the resulting mathematical relations.<br>• For specific applications, they are able to self-reliantly find necessary physico-chemical properties of compounds as well as model parameters in literature sources.<br>• Beside pure compound properties the students are capable of describing the properties of mixtures.<br>• The students know how to visualize phase equilibria graphically and they know how to interpret the occurring phenomena.<br>• Based on their knowledge, the students are able to understand fundamental concepts that are the basis for many separation and reaction processes in chemical engineering. |
| **Personal Competence** | |
| *Social Competence* | The students are able to work in small groups, to solve the corresponding problems and to present them oraly to the tutors and other students |
| *Autonomy* | • The students are able to find necessary information self-reliantly in literature sources and to judge their quality.<br>• During the semester the students are able to check their learning progress continuously in exercises. Based on this knowledge the students can adept their learning process. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes; theoretical questions and calculations |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0114: Phase Equilibria Thermodynamics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction: Applications of thermodynamics of mixtures<br>2. Thermodynamic equations in multi-component systems: Fundamental equations, chemical potential, fugacity<br>3. Phase equilibria of pure substances: thermodynamic equilibrium, vapor pressure, Gibbs' phase rule<br>4. Equations of state: virial equations, van-der-Waals equation, generalized equations of state<br>5. Mixing properties: ideal and real mixtures, excess properties, partial molar properties<br>6. Vapor-liquid-equilibria: binary systems, azeotropes, equilibrium condition<br>7. Gas-liquid-equilibria: equilibrium condition, Henry-coefficient<br>8. $G^E$-Models: Hildebrand-model, Flory-Huggins-model, Wilson-model, UNIQUAC, UNIFAC<br>9. Liquid-liquid-equilibria: equilibrium condition, phase equilibria in binary and ternary systems<br>10. Solid-liquid-equilibria: equilibrium condition, binary systems<br>11. Chemical reactions: reaction coordinate, mass action law, influence of pressure and temperature<br>12. Osmotic pressure |
| **Literature** | • Jürgen Gmehling, Bärbel Kolbe: Thermodynamik. VCH 1992<br>• J.M. Prausnitz, R.N. Lichtenthaler, E.G. de Azevedo: Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed. Prentice Hall, 1999.<br>• J.W. Tester, M. Modell: Thermodynamics and its Applications. 3 rd ed. Prentice Hall, 1997.J.P. O´Connell, J.M. Haile: Thermodynamics. Cambridge University Press, 2005. |

| Course L0140: Phase Equilibria Thermodynamics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction: Applications of thermodynamics of mixtures<br>2. Thermodynamic equations in multi-component systems: Fundamental equations, chemical potential, fugacity<br>3. Phase equilibria of pure substances: thermodynamic equilibrium, vapor pressure, Gibbs' phase rule<br>4. Equations of state: virial equations, van-der-Waals equation, generalized equations of state<br>5. Mixing properties: ideal and real mixtures, excess properties, partial molar properties<br>6. Vapor-liquid-equilibria: binary systems, azeotropes, equilibrium condition<br>7. Gas-liquid-equilibria: equilibrium condition, Henry-coefficient<br>8. $G^E$-Models: Hildebrand-model, Flory-Huggins-model, Wilson-model, UNIQUAC, UNIFAC<br>9. Liquid-liquid-equilibria: equilibrium condition, phase equilibria in binary and ternary systems<br>10. Solid-liquid-equilibria: equilibrium condition, binary systems<br>11. Chemical reactions: reaction coordinate, mass action law, influence of pressure and temperature<br>12. Osmotic pressure<br><br>The students work on tasks in small groups and present their results in front of all students. |
| **Literature** | • Jürgen Gmehling, Bärbel Kolbe: Thermodynamik. VCH 1992<br>• J.M. Prausnitz, R.N. Lichtenthaler, E.G. de Azevedo: Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed. Prentice Hall, 1999.<br>• J.W. Tester, M. Modell: Thermodynamics and its Applications. 3rd ed. Prentice Hall, 1997.J.P. O´Connell, J.M. Haile: Thermodynamics. Cambridge University Press, 2005. |

| **Course L0142: Phase Equilibria Thermodynamics** | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction: Applications of thermodynamics of mixtures<br>2. Thermodynamic equations in multi-component systems: Fundamental equations, chemical potential, fugacity<br>3. Phase equilibria of pure substances: thermodynamic equilibrium, vapor pressure, Gibbs' phase rule<br>4. Equations of state: virial equations, van-der-Waals equation, generalized equations of state<br>5. Mixing properties: ideal and real mixtures, excess properties, partial molar properties<br>6. Vapor-liquid-equilibria: binary systems, azeotropes, equilibrium condition<br>7. Gas-liquid-equilibria: equilibrium condition, Henry-coefficient<br>8. $G^E$-Models: Hildebrand-model, Flory-Huggins-model, Wilson-model, UNIQUAC, UNIFAC<br>9. Liquid-liquid-equilibria: equilibrium condition, phase equilibria in binary and ternary systems<br>10. Solid-liquid-equilibria: equilibrium condition, binary systems<br>11. Chemical reactions: reaction coordinate, mass action law, influence of pressure and temperature<br>12. Osmotic pressure |
| **Literature** | • Jürgen Gmehling, Bärbel Kolbe: Thermodynamik. VCH 1992<br>• J.M. Prausnitz, R.N. Lichtenthaler, E.G. de Azevedo: Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed. Prentice Hall, 1999.<br>• J.W. Tester, M. Modell: Thermodynamics and its Applications. 3rd ed. Prentice Hall, 1997.J.P. O´Connell, J.M. Haile: Thermodynamics. Cambridge University Press, 2005. |

## Module M0829: Foundations of Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Management Tutorial (L0882) | Recitation Section (small) | 2 | 3 |
| Introduction to Management (L0880) | Lecture | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Christian Lüthje |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic Knowledge of Mathematics and Business |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After taking this module, students know the important basics of many different areas in Business and Management, from Planning and Organisation to Marketing and Innovation, and also to Investment and Controlling. In particular they are able to<br>• explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management<br>• explain the most important aspects of and goals in Management and name the most important aspects of entreprneurial projects<br>• describe and explain basic business functions as production, procurement and sourcing, supply chain management, organization and human ressource management, information management, innovation management and marketing<br>• explain the relevance of planning and decision making in Business, esp. in situations under multiple objectives and uncertainty, and explain some basic methods from mathematical Finance<br>• state basics from accounting and costing and selected controlling methods. |
| *Skills* | Students are able to analyse business units with respect to different criteria (organization, objectives, strategies etc.) and to carry out an Entrepreneurship project in a team. In particular, they are able to<br>• analyse Management goals and structure them appropriately<br>• analyse organisational and staff structures of companies<br>• apply methods for decision making under multiple objectives, under uncertainty and under risk<br>• analyse production and procurement systems and Business information systems<br>• analyse and apply basic methods of marketing<br>• select and apply basic methods from mathematical finance to predefined problems<br>• apply basic methods from accounting, costing and controlling to predefined problems |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• work successfully in a team of students<br>• to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project<br>• to communicate appropriately and<br>• to cooperate respectfully with their fellow students. |
| *Autonomy* | Students are able to<br>• work in a team and to organize the team themselves<br>• to write a report on their project. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | several written exams during the semester plus final test (90 minutes) |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Specialisation Biomechanics: Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Compulsory |

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|---|---|
| | Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory<br>Mechanical Engineering: Specialisation Product Development and Production: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| **Course L0882: Management Tutorial** | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Lüthje, Katharina Roedelius |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | In the management tutorial, the contents of the lecture will be deepened by practical examples and the application of the discussed tools.<br><br>If there is adequate demand, a problem-oriented tutorial will be offered in parallel, which students can choose alternatively. Here, students work in groups on se selected projects that focus on the elaboration of an innovative business idea from the point of view of an established company or a startup. Again, the busin knowledge from the lecture should come to practical use. The group projects are guided by a mentor. |
| **Literature** | Relevante Literatur aus der korrespondierenden Vorlesung. |

| Course L0880: Introduction to Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Matthias Meyer, Prof. Christian Lüthje, Prof. Christian Ringle, Prof. Christian Thies, Prof. Christoph Ihl, Prof. Kathrin Fischer, Prof. Moritz Göldner, Prof. Thomas Wrona, Prof. Thorsten Blecker, Prof. Tim Schweisfurth, Prof. Wolfgang Kersten |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | • Introduction to Business and Management, Business versus Economics, relevant areas in Business and Management<br>• Important definitions from Management,<br>• Developing Objectives for Business, and their relation to important Business functions<br>• Business Functions: Functions of the Value Chain, e.g. Production and Procurement, Supply Chain Management, Innovation Management, Marketing and Sales<br>Cross-sectional Functions, e.g. Organisation, Human Ressource Management, Supply Chain Management, Information Management<br>• Definitions as information, information systems, aspects of data security and strategic information systems<br>• Definition and Relevance of innovations, e.g. innovation opporunities, risks etc.<br>• Relevance of marketing, B2B vs. B2C-Marketing<br>• different techniques from the field of marketing (e.g. scenario technique), pricing strategies<br>• important organizational structures<br>• basics of human ressource management<br>• Introduction to Business Planning and the steps of a planning process<br>• Decision Analysis: Elements of decision problems and methods for solving decision problems<br>• Selected Planning Tasks, e.g. Investment and Financial Decisions<br>• Introduction to Accounting: Accounting, Balance-Sheets, Costing<br>• Relevance of Controlling and selected Controlling methods<br>• Important aspects of Entrepreneurship projects |
| **Literature** | Bamberg, G., Coenenberg, A.: Betriebswirtschaftliche Entscheidungslehre, 14. Aufl., München 2008<br><br>Eisenführ, F., Weber, M.: Rationales Entscheiden, 4. Aufl., Berlin et al. 2003<br><br>Heinhold, M.: Buchführung in Fallbeispielen, 10. Aufl., Stuttgart 2006.<br><br>Kruschwitz, L.: Finanzmathematik. 3. Auflage, München 2001.<br><br>Pellens, B., Fülbier, R. U., Gassen, J., Sellhorn, T.: Internationale Rechnungslegung, 7. Aufl., Stuttgart 2008.<br><br>Schweitzer, M.: Planung und Steuerung, in: Bea/Friedl/Schweitzer: Allgemeine Betriebswirtschaftslehre, Bd. 2: Führung, 9. Aufl., Stuttgart 2005.<br><br>Weber, J., Schäffer, U. : Einführung in das Controlling, 12. Auflage, Stuttgart 2008.<br><br>Weber, J./Weißenberger, B.: Einführung in das Rechnungswesen, 7. Auflage, Stuttgart 2006. |

## Specialization Energy Technology

The aim of the specialisation "Energy Technology" is to enable students to plan and calculate plants and machines and to familiarise them with various technologies for energy conversion, energy distribution and energy application. Processes can be analysed, abstracted and modelled using scientific methods. Students can assess data and results and use them to develop strategies for innovative solutions.

### Module M0594: Fundamentals of Mechanical Engineering Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Mechanical Engineering Design (L0258) | Lecture | 2 | 3 |
| Fundamentals of Mechanical Engineering Design (L0259) | Recitation Section (large) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Basic knowledge about mechanics and production engineering<br>• Internship (Stage I Practical) |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After passing the module, students are able to:<br>• explain basic working principles and functions of machine elements,<br>• explain requirements, selection criteria, application scenarios and practical examples of basic machine elements, indicate the background of dimensioning calculations. |
| *Skills* | After passing the module, students are able to:<br>• accomplish dimensioning calculations of covered machine elements,<br>• transfer knowledge learned in the module to new requirements and tasks (problem solving skills),<br>• recognize the content of technical drawings and schematic sketches,<br>• technically evaluate basic designs. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to discuss technical information in the lecture supported by activating methods. |
| *Autonomy* | • Students are able to independently deepen their acquired knowledge in exercises.<br>• Students are able to acquire additional knowledge and to recapitulate poorly understood content e.g. by using the video recordings of the lectures. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory |

| Course L0258: Fundamentals of Mechanical Engineering Design | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Nikola Bursac, Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | **Lecture**<br>• Introduction to design<br>• Introduction to the following machine elements<br>  ◦ Screws<br>  ◦ Shaft-hub joints<br>  ◦ Rolling contact bearings<br>  ◦ Welding / adhesive / solder joints<br>  ◦ Springs<br>  ◦ Axes & shafts<br>• Presentation of technical objects (technical drawing)<br>**Exercise**<br>• Calculation methods for dimensioning the following machine elements:<br>  ◦ Screws<br>  ◦ Shaft-hub joints<br>  ◦ Rolling contact bearings<br>  ◦ Welding / adhesive / solder joints<br>  ◦ Springs<br>  ◦ Axis & shafts |
| **Literature** | • Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage.<br>• Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage.<br>• Einführung in die DIN-Normen; Klein, M., Teubner-Verlag.<br>• Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage.<br>• Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage.<br>• Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage.<br>• Sowie weitere Bücher zu speziellen Themen |

| Course L0259: Fundamentals of Mechanical Engineering Design | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Nikola Bursac, Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1713: Green Technologies III

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Study Work Green Technologies (L2766) | Project Seminar | 2 | 4 |
| Scientific Work and Writing (L2765) | Seminar | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Dozenten des Studiengangs |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | keine |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students, based on a literature survey, learn to study in detail a subject theme from the disciplines of green technologies and deliver afterwards a summary presentation to a specialised audience. Environmental issues and their multidisciplinary linkages are preferred, when selecting the thematic area of these studies. Through their own written contribution the students communicate an overview over the subject and practice technical writing. With the discussion the students practice scientific debating on a specialised subject matter. |
| *Skills* | The students can, when working on a technical topic not familiar to them:<br>• conduct a literature survey<br>• choose the relevant information for their presentation<br>• prepare a written summary<br>• present results in front of peers and staff<br>• correctly cite and reference sources. |
| **Personal Competence** | |
| *Social Competence* | The students practice a critical assessment of the literature in a predefined specialised theme and learn to give presentations on their own technical sub-topic tailored to their public and discuss with the audience. When attending technical presentations, the students can formulate questions to other speakers and participate in the ensuing discussion.<br>The fulfilment of the tasks combines independent work with group and teamwork. |
| *Autonomy* | The students can, guided by instructors, critically reflect on their learning and work status, and write a scientific report. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Study work |
| **Examination duration and scale** | - |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory |

### Course L2766: Study Work Green Technologies

| | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Studiengangs |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Students carry out a research project in a scientific field under the guidance of an academic staff member. For this purpose, the student can approach the staff of the respective institute and discuss a topic. The topic is then worked on within 4 weeks and regular consultations are held with the supervisor. The student research project should be the size of a scientific article and must be presented to the lecturer after completion as part of a presentation (approx. 15 minutes). |
| **Literature** | |

| Course L2765: Scientific Work and Writing | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Studiengangs, Dr. Detlev Bieler, Florian Hagen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The seminar offers an introduction into the diverse aspects of academic research and writing: Finding the topic, finding specialized information, knowledge organisation, writing, presenting and publishing. Suggestions for reflecting own processes of learning, informing and writing - in addition to practical recommendations and tips - facilitate the start and the creation of bachelor and master theses, works, which bring thoroughly self-fulfillment and make fun.<br><br>Topics of the seminar will be in particular<br><br>• Scientific scholarship and academic research methods:<br>• Introduction, organization, attributes of science:<br>How is scientific knowledge created?<br>Work scheduling, finding topics, time management, specialities of academic research in engineering<br>• Finding specialized information: Full texts and library resources, databases http://www.tub.tuhh.de/en/subject-information/informing-points-to-survive/<br>• Reference management: http://www.tub.tuhh.de/en/publishing/reference-management/<br>Knowledge organisation and creating publications with Citavi<br>• Citing correctly and avoiding plagiarism<br>• Preparing and doing presentations |
| **Literature** | 1. Semesterapparat "Wissenschaftliches Arbeiten" in der TU-Bibliothek: http://tinyurl.com/Semesterapparat-Wiss-Arbeiten<br>2. Weblog Wissenschaftliches Arbeiten der TU-Bibliothek: https://www.tub.tuhh.de/wissenschaftliches-arbeiten/<br>3. Online-Tutorial VISION der TU-Bibliothek zum wissenschaftlichen Arbeiten: https://www.vision.tuhh.de (funktioniert nur mit installiertem Flash)<br>4. Andreas Hirsch-Weber, Stefan Scherer: Wissenschaftliches Arbeiten und Abschlussarbeit in Natur- und Ingenieurwissenschaften : Grundlagen, Praxisbeispiele, Übungen. Stuttgart: Ulmer, 2016.<br>5. Werner Sesink: Einführung in das wissenschaftliche Arbeiten : inklusive E-Learning, Web-Recherche, digitale Präsentation u.a. 9., aktualisierte Aufl. München : Oldenbourg, 2012.<br>6. Judith Theuerkauf: Schreiben im Ingenieurstudium : effektiv und effizient zur Bachelor-, Master- und Doktorarbeit. Paderborn : Schöningh, 2012.<br>7. Wolfsberger, Judith: Frei geschrieben : Mut, Freiheit & Strategie für wissenschaftliche Abschlussarbeiten. Wien: Böhlau, 2010<br>8. Biedermann, Wieland u.a.: Forschungsmethodik in den Ingenieurwissenschaften : Skript vom Lehrstuhl für Produktentwicklung, Prof. Dr.-Ing. Udo Lindemann, Technische Universität München (TUM), 2012. https://www.mw.tum.de/fileadmin/w00btx/lpl/Documents/Forschungsmethodik_Skript.pdf<br>9. Wissenschaftliches Arbeiten - HOOU Angebot der HCU Hamburg: https://blogs.hoou.de/wissarbeiten/<br><br>1. Course Reserves Collection "Scholarly Research Methods" in the TUHH library: http://tinyurl.com/Semesterapparat-Wiss-Arbeiten<br>2. Scholarly research methods via TUHH library Website: https://www.tub.tuhh.de/en/scholarly-research-methods/<br>3. VISION - Online-Tutorial on research methods by the TUHH library: http://www.vision.tuhh.de (Flash has to be installed)<br>4. Scientific papers and presentations / Martha Davis. 3. ed. Amsterdam: Elsevier / Academic Press, 2013. http://www.sciencedirect.com/science/book/9780123847270<br>5. Writing for science and engineering : papers, presentations and reports / Heather Silyn-Roberts. 2nd ed. Amsterdam : Elsevier, 2013. http://www.sciencedirect.com/science/book/9780080982854<br>6. How to research / Loraine Blaxter, Christina Hughes and Malcolm Tight. Maidenhead : Open Univ. Press, 2010.<br>7. Managing information for research : practical help in researching, writing and designing dissertations / Elizabeth Orna and Graham Stevens. Maidenhead : Open University Press McGraw-Hill, 2009.<br>8. Writing scientific research articles : strategy and steps / Margaret Cargill and Patrick O'Connor. Chichester : Wiley-Blackwell, 2009. |

## Module M1022: Reciprocating Machinery

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines (L0633) | Lecture | 1 | 1 |
| Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines (L0634) | Recitation Section (large) | 1 | 1 |
| Internal Combustion Engines I (L0059) | Lecture | 2 | 2 |
| Internal Combustion Engines I (L0639) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Christopher Friedrich Wirz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Thermodynamics, Mechanics, Machine Elements |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | As a result of the part module „Fundamentals of Reciprocating Machinery", the students are able to reflect fundamentals regarding power and working machinery and describe the qualitative and quantitative correlations of operating methods and efficiencies of multiple types of engines, compressors and pumps. They are able to utilize technical terms and parameters as well as aspects regarding the development of power density and efficiency, furthermore to give an overview of charging systems, fuels and emissions. The students are able to select specific types of machinery and assess design related and operational problems.<br><br>As a result of the part module "Internal Combustion Engines I", the students are able reflect and utilize the state-of-the-art regarding efficiency limits. In addition, they are able to utilize their knowledge of design, mechanical and thermodynamic characteristics and the approach of similarity. They are able to explain, assess and develop engines as well as charging systems. Detailed knowledge is present regarding computer-aided process design. |
| *Skills* | The students are skilled to employ basic and detail knowledge regarding reciprocating machinery, their selection and operation. They are further able to assess, analyse and solve technical and operational problems and to perform mechanical and thermodynamic design. |
| **Personal Competence** | |
| *Social Competence* | The students are able to communicate and cooperate in a professional environment in the field of machinery design and application. |
| *Autonomy* | The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Compulsory |

| Course L0633: Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Christopher Friedrich Wirz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Verbrennungsmotoren<br>  ◦ Historischer Rückblick<br>  ◦ Einteilung der Verbrennungsmotoren<br>  ◦ Arbeitsverfahren<br>  ◦ Vergleichsprozesse<br>  ◦ Arbeit, Mitteldrücke, Leistungen<br>  ◦ Arbeitsprozess des wirklichen Motors<br>  ◦ Wirkungsgrade<br>  ◦ Gemischbildung und Verbrennung<br>  ◦ Motorkennfeld und Betriebskennlinien<br>  ◦ Abgasentgiftung<br>  ◦ Gaswechsel<br>  ◦ Aufladung<br>  ◦ Kühl- und Schmiersystem<br>  ◦ Kräfte im Triebwerk<br>• Kolbenverdichter<br>  ◦ Thermodynamik des Kolbenverdichters<br>  ◦ Einteilung und Verwendung<br>• Kolbenpumpen<br>  ◦ Prinzip der Kolbenpumpen<br>  ◦ Einteilung und Verwendung |
| **Literature** | • A. Urlaub: Verbrennungsmotoren<br>• W. Kalide: Kraft- und Arbeitsmaschinen |

| Course L0634: Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Christopher Friedrich Wirz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0059: Internal Combustion Engines I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christopher Severin |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • The beginnings of engine development<br>• Design of of motors<br>• Real process calculation<br>• Charging methods<br>• Kinematics of the crank mechanism<br>• Forces in the engine |
| **Literature** | • Vorlesungsskript<br>• Übungsaufgaben mit Lösungsweg<br>• Literaturliste |

| Course L0639: Internal Combustion Engines I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Christopher Severin |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0598: Mechanical Engineering: Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Embodiment Design and 3D-CAD Introduction and Practical Training (L0268) | Lecture | 2 | 1 |
| Mechanical Design Project I (L0695) | Project-/problem-based Learning | 3 | 2 |
| Mechanical Design Project II (L0592) | Project-/problem-based Learning | 3 | 2 |
| Team Project Design Methodology (L0267) | Project-/problem-based Learning | 2 | 1 |

**Module Responsible**: Prof. Dieter Krause

**Admission Requirements**: None

**Recommended Previous Knowledge**

- Fundamentals of Mechanical Engineering Design
- Mechanics
- Fundamentals of Materials Science
- Production Engineering

**Educational Objectives**: After taking part successfully, students have reached the following learning results

**Professional Competence**

*Knowledge*: After passing the module, students are able to:

- explain design guidelines for machinery parts e.g. considering load situation, materials and manufacturing requirements,
- describe basics of 3D CAD,
- explain basics methods of engineering designing.

*Skills*: After passing the module, students are able to:

- independently create sketches, technical drawings and documentations e.g. using 3D CAD,
- design components based on design guidelines autonomously,
- dimension (calculate) used components,
- use methods to design and solve engineering design tasks systamtically and solution-oriented,
- apply creativity techniques in teams.

**Personal Competence**

*Social Competence*: After passing the module, students are able to:

- develop and evaluate solutions in groups including making and documenting decisions,
- moderate the use of scientific methods,
- present and discuss solutions and technical drawings within groups,
- reflect the own results in the work groups of the course.

*Autonomy*: Students are able

- to estimate their level of knowledge using activating methods within the lectures (e.g. with clickers),
- To solve engineering design tasks systematically.

**Workload in Hours**: Independent Study Time 40, Study Time in Lecture 140

**Credit points**: 6

**Course achievement**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| Yes | None | Written elaboration | Konstruktionsprojekt 1 |
| Yes | None | Written elaboration | Konstruktionsprojekt 2 |
| Yes | None | Written elaboration | 3D-CAD-Praktikum |
| Yes | None | Written elaboration | Teamprojekt Konstruktionsmethodik |

**Examination**: Written exam

**Examination duration and scale**: 180 min

**Assignment for the Following Curricula**

General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Compulsory
General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
Digital Mechanical Engineering: Core Qualification: Compulsory
Engineering Science: Specialisation Mechanical Engineering: Compulsory
Engineering Science: Specialisation Biomedical Engineering: Compulsory
Engineering Science: Specialisation Mechatronics: Compulsory
Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory
Mechanical Engineering: Core Qualification: Compulsory
Mechatronics: Core Qualification: Compulsory
Naval Architecture: Core Qualification: Compulsory

| Course L0268: Embodiment Design and 3D-CAD Introduction and Practical Training | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Basics of 3D CAD technology<br>• Practical course to apply a 3D CAD system<br>  ◦ Introduction to the system<br>  ◦ Sketching and creation of components<br>  ◦ Creation of assemblies<br>  ◦ Deriving technical drawings |
| **Literature** | • CAx für Ingenieure eine praxisbezogene Einführung; Vajna, S., Weber, C., Bley, H., Zeman, K.; Springer-Verlag, aktuelle Auflage.<br>• Handbuch Konstruktion; Rieg, F., Steinhilper, R.; Hanser; aktuelle Auflage.<br>• Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage.<br>• Technisches Zeichnen: Grundlagen, Normen, Beispiele, Darstellende Geometrie, Hoischen, H; Hesser, W; Cornelsen, aktuelle Auflage.<br>• Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage.<br>• Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage.<br>• Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage.<br>• Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage.<br>• Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage. |

| Course L0695: Mechanical Design Project I | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 18, Study Time in Lecture 42 |
| **Lecturer** | Prof. Thorsten Schüppstuhl |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Create a technical documentation of an existing mechanical model<br>• Consolidation of the following aspects of technical drawings:<br>  ◦ Presentation of technical objects and standardized parts<br>  (bearings, seals, shaft-hub joints, detachable connections, springs, axes and shafts)<br>  ◦ Sectional views<br>  ◦ Dimensioning<br>  ◦ Tolerances and surface specifications<br>  ◦ Creating a tally sheet |
| **Literature** | 1. Hoischen, H.; Hesser, W.: Technisches Zeichnen. Grundlagen, Normen, Beispiele, darstellende Geometrie, 33. Auflage. Berlin 2011.<br>2. Labisch, S.; Weber, C.: Technisches Zeichnen. Selbstständig lernen und effektiv üben, 4. Auflage. Wiesbaden 2008.<br>3. Fischer, U.: Tabellenbuch Metall, 43. Auflage. Haan-Gruiten 2005. |

| Course L0592: Mechanical Design Project II | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 18, Study Time in Lecture 42 |
| **Lecturer** | Prof. Jan Hendrik Dege |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Generation of sketches for functions and sub-functions<br>• Approximately calculation of shafts<br>• Dimension of bearings, screw connections and weld<br>• Generation of engineering drawings (assembly drawings, manufacturing drawing) |
| **Literature** | **Dubbel, Taschenbuch für Maschinenbau**, Beitz, W., Küttner, K.-H, Springer-Verlag.<br><br>Maschinenelemente, Band I - III, Niemann, G., Springer-Verlag.<br><br>**Maschinen- und Konstruktionselemente**, Steinhilper, W., Röper, R., Springer-Verlag.<br><br>Einführung in die DIN-Normen, Klein, M., Teubner-Verlag.<br><br>Konstruktionslehre, Pahl, G., Beitz, W., Springer-Verlag. |

| Course L0267: Team Project Design Methodology | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction to engineering designing methodology<br>• Team Project Design Methodology<br>  ◦ Creating requirement lists<br>  ◦ Problem formulation<br>  ◦ Creating functional structures<br>  ◦ Finding solutions<br>  ◦ Evaluation of the found concepts<br>  ◦ Documentation of the taken methodological steps and the concepts using presentation slides |
| **Literature** | • Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage.<br>• Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage.<br>• Einführung in die DIN-Normen; Klein, M., Teubner-Verlag.<br>• Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage.<br>• Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage.<br>• Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage.<br>• Sowie weitere Bücher zu speziellen Themen |

## Module M0933: Fundamentals of Materials Science

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Materials Science I (L1085) | Lecture | 2 | 2 |
| Fundamentals of Materials Science II (Advanced Ceramic Materials, Polymers and Composites) (L0506) | Lecture | 2 | 2 |
| Physical and Chemical Basics of Materials Science (L1095) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Jörg Weißmüller |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Highschool-level physics, chemistry und mathematics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students have acquired a fundamental knowledge on metals, ceramics and polymers and can describe this knowledge comprehensively. Fundamental knowledge here means specifically the issues of atomic structure, microstructure, phase diagrams, phase transformations, corrosion and mechanical properties. The students know about the key aspects of characterization methods for materials and can identify relevant approaches for characterizing specific properties. They are able to trace materials phenomena back to the underlying physical and chemical laws of nature. |
| *Skills* | The students are able to trace materials phenomena back to the underlying physical and chemical laws of nature. Materials phenomena here refers to mechanical properties such as strength, ductility, and stiffness, chemical properties such as corrosion resistance, and to phase transformations such as solidification, precipitation, or melting. The students can explain the relation between processing conditions and the materials microstructure, and they can account for the impact of microstructure on the material's behavior. |
| **Personal Competence** | |
| *Social Competence* | - |
| *Autonomy* | - |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>Data Science: Specialisation II. Application: Elective Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory |

### Course L1085: Fundamentals of Materials Science I

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jörg Weißmüller |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | Vorlesungsskript<br><br>W.D. Callister: Materials Science and Engineering - An Introduction. 5th ed., John Wiley & Sons, Inc., New York, 2000, ISBN 0-471-32013-7<br><br>P. Haasen: Physikalische Metallkunde. Springer 1994 |

| Course L0506: Fundamentals of Materials Science II (Advanced Ceramic Materials, Polymers and Composites) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Bodo Fiedler, Prof. Gerold Schneider |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Chemische Bindungen und Aufbau von Festkörpern; Kristallaufbau; Werkstoffprüfung; Schweißbarkeit; Herstellung von Keramiken; Aufbau und Eigenschaften der Keramik; Herstellung, Aufbau und Eigenschaften von Gläsern; Polymerwerkstoffe, Makromolekularer Aufbau; Struktur und Eigenschaften der Polymere; Polymerverarbeitung; Verbundwerkstoffe |
| **Literature** | Vorlesungsskript<br><br>W.D. Callister: Materials Science and Engineering -An Introduction-5th ed., John Wiley & Sons, Inc., New York, 2000, ISBN 0-471-32013-7 |

| Course L1095: Physical and Chemical Basics of Materials Science | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Gregor Vonbun-Feldbauer |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Motivation: „Atoms in Mechanical Engineering?“<br>• Basics: Force and Energy<br>• The electromagnetic Interaction<br>• „Detour“: Mathematics (complex e-funktion etc.)<br>• The atom: Bohr's model of the atom<br>• Chemical bounds<br>• The multi part problem: Solutions and strategies<br>• Descriptions of using statistical thermodynamics<br>• Elastic theory of atoms<br>• Consequences of atomar properties on makroskopic Properties: Discussion of examples (metals, semiconductors, hybrid systems) |
| **Literature** | Für den **Elektromagnetismus:**<br>• Bergmann-Schäfer: „Lehrbuch der Experimentalphysik“, Band 2: „Elektromagnetismus“, de Gruyter<br>Für die **Atomphysik:**<br>• Haken, Wolf: „Atom- und Quantenphysik“, Springer<br>Für die **Materialphysik und Elastizität:**<br>• Hornbogen, Warlimont: „Metallkunde“, Springer |

## Module M0662: Numerical Mathematics I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Numerical Mathematics I (L0417) | Lecture | 2 | 3 |
| Numerical Mathematics I (L0418) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Sabine Le Borne |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Mathematik I + II for Engineering Students (german or english) **or** Analysis & Linear Algebra I + II for Technomathematicians<br>• basic MATLAB/Python knowledge |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to<br>• name numerical methods for interpolation, integration, least squares problems, eigenvalue problems, nonlinear root finding problems and to explain their core ideas,<br>• repeat convergence statements for the numerical methods,<br>• explain aspects for the practical execution of numerical methods with respect to computational and storage complexitx. |
| *Skills* | Students are able to<br>• implement, apply and compare numerical methods using MATLAB/Python,<br>• justify the convergence behaviour of numerical methods with respect to the problem and solution algorithm,<br>• select and execute a suitable solution approach for a given problem. |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms. |
| *Autonomy* | Students are capable<br>• to assess whether the supporting theoretical and practical excercises are better solved individually or in a team,<br>• to assess their individual progess and, if necessary, to ask questions and seek help. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Data Science: Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Engineering Science: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory |

| Course L0417: Numerical Mathematics I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sabine Le Borne |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | 1. Finite precision arithmetic, error analysis, conditioning and stability<br>2. Linear systems of equations: LU and Cholesky factorization, condition<br>3. Interpolation: polynomial, spline and trigonometric interpolation<br>4. Nonlinear equations: fixed point iteration, root finding algorithms, Newton's method<br>5. Linear and nonlinear least squares problems: normal equations, Gram Schmidt and Householder orthogonalization, singular value decomposition, regularizatio, Gauss-Newton and Levenberg-Marquardt methods<br>6. Eigenvalue problems: power iteration, inverse iteration, QR algorithm<br>7. Numerical differentiation<br>8. Numerical integration: Newton-Cotes rules, error estimates, Gauss quadrature, adaptive quadrature |
| **Literature** | • Gander/Gander/Kwok: Scientific Computing: An introduction using Maple and MATLAB, Springer (2014)<br>• Stoer/Bulirsch: Numerische Mathematik 1, Springer<br>• Dahmen, Reusken: Numerik für Ingenieure und Naturwissenschaftler, Springer |

| Course L0418: Numerical Mathematics I | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sabine Le Borne, Dr. Jens-Peter Zemke |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0655: Computational Fluid Dynamics I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Computational Fluid Dynamics I (L0235) | Lecture | 2 | 3 |
| Computational Fluid Dynamics I (L0419) | Recitation Section (large) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Thomas Rung |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Students should have sound knowledge of engineering mathematics (series expansions, internal & vector calculus), and be familiar with the foundations of partial/ordinary differential equations. They should also be familiar with engineering fluid mechanics and thermodynamics. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will have the required combined knowledge of thermo-/fluid dynamics and numerical analysis to translate general principles of thermo-/fluid engineering into discrete algorithms on the basis of local (finite differences/volumes) and global (potential theory) ansatz functions. They are familiar with the similarities and differences between different discretisation and approximation concepts for investigating coupled systems of non-linear, convective partial differential equations (PDE), and explain the motivation for applying them. Students have the required background knowledge to develop, code, explain and apply numerical algorithms dedicated to the solution of thermofluid dynamic PDEs. They are familiar with most numerical methods used to predict thermofluid dynamic fields, in particular their realms and limitations. |
| *Skills* | The students are able choose and apply appropriate numerical procedures that integrate the governing thermofluid dynamic PDEs in space and time. They can apply/optimise numerical analysis concepts to/for fluid dynamic applications. They can code computational algorithms in a structured way, apply these codes for parameter investigations and supplement interfaces to extract simulation data for an engineering analysis. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss problems, present the results of their own analysis, and jointly develop, implement and report on solution strategies that address given technical reference problems. |
| *Autonomy* | The students can independently analyse numerical methods to solving fluid engineering problems. They are able to critically analyse own results as well as external data with regards to the plausibility and reliability. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 2h |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L0235: Computational Fluid Dynamics I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thomas Rung |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Fundamentals of computational modelling of thermofluid dynamic problems. Development of numerical algorithms.<br>1. Partial differential equations<br>2. Foundations of finite numerical approximations<br>3. Computation of potential flows<br>4. Introduction of finite-differences<br>5. Approximation of convective, diffusive and transient transport processes<br>6. Formulation of boundary conditions and initial conditions<br>7. Assembly and solution of algebraic equation systems<br>8. Facets of weighted -residual approaches<br>9. Finite volume methods<br>10. Basics of grid generation |
| **Literature** | Ferziger and Peric: *Computational Methods for Fluid Dynamics*, Springer |

| Course L0419: Computational Fluid Dynamics I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thomas Rung |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0639: Gas and Steam Power Plants

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Gas and Steam Power Plants (L0206) | Lecture | 3 | 5 |
| Gas and Steam Power Plants (L0210) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Dozenten des SD M |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • "Technical Thermodynamics I and II"<br>• "Heat Transfer"<br>• "Fluid Mechanics" |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can evaluate the development of the electricity demand and the energy conversion routes in the thermal power plant, describe the various types of power plant and the layout of the steam generator block. They are also able to determine the operation characteristics of the power plant. Additionally they can describe the exhaust gas cleaning apparatus and the combination possibilities of conventional fossil-fuelled power plants with solar thermal and geothermal power plants or plants equipped with Carbon Capture and Storage.<br><br>The students have basic knowledge about the principles, operation and design of turbomachinery |
| *Skills* | The students will be able, using theories and methods of the energy technology from fossil fuels and based on well-founded knowledge on the function and construction of gas and steam power plants, to identify basic associations in the production of heat and electricity, so as to develop conceptual solutions. Through analysis of the problem and exposure to the inherent interplay between heat and power generation the students are endowed with the capability and methodology to develop realistic optimal concepts for the generation of electricity and the production of heat. From the technical basics the students become the ability to follow better the deliberations on the electricity mix composition within the energy-political triangle (economy, secure supply and environmental protection).<br><br>Within the framework of the exercise the students learn the use of the specialised software suite EBSILON Professional ™. With this tool small practical tasks are solved with the PC, to highlight aspects of the design and development of power plant cycles.<br><br>The students are able to do simplified calculations on turbomachinery either as part of a plant, as single component or at stage level. |
| **Personal Competence** | |
| *Social Competence* | An excursion within the framework of the lecture is planned for students that are interested. The students get in this manner direct contact with a modern power plant in this region. The students will obtain first-hand experience with a power plant in operation and gain insights into the conflicts between technical and political issues. |
| *Autonomy* | The students assisted by the tutors will be able to develop alone simple simulation models and run with these scenario analyses. In this manner the theoretical and practical knowledge from the lecture is consolidated and the potential effects from different process combinations and boundary conditions highlighted. The students are able independently to analyse the operational performance of steam power plants and calculate selected quantities and characteristic curves. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |

**Course achievement**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| No | 5 % | Presentation | 15-minütiges, unbenotetes Testat über EBSILON Professional; nur bestanden/nicht bestanden (keine anteiligen Punkte) |
| No | 5 % | Excercises | Sechs Übungsaufgaben mit Ebsilon-Professional, bis zu insgesamt 5 % Bonus je nach Anteil richtiger Abgaben |

| | |
|---|---|
| **Examination** | Written exam |
| **Examination duration and scale** | Written examination of 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory |

| Course L0206: Gas and Steam Power Plants | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 5 |
| **Workload in Hours** | Independent Study Time 108, Study Time in Lecture 42 |
| **Lecturer** | Dr. Lars Wiese, Dr. Stylianos Rafailidis |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | In the 1st part of the lecture an overview on thermal power plants is offered, including:<br>• Electricity demand and Forecasting<br>• Thermodynamic fundamentals<br>• Energy Conversion in thermal power plants<br>• Types of power plant<br>• Layout of the power plant block<br>• Individual elements of the power plant<br>• Cooling systems<br>• Flue gas cleaning<br>• Operation characteristics of the power plant<br>• Construction materials for power plants<br>• Location of power plants<br>• Solar thermal plants/geothermal plants/Carbon Capture and Storage plants.<br>These are complemented in the 2nd part of the module by the more specialised issues:<br>• Energy balance of a turbomachine<br>• Theory of turbine and compressor stage<br>• Equal and positive pressure blading<br>• Flow losses<br>• Characteristic numbers<br>• Axial and radial design<br>• Design features<br>• Hydraulic turbomachines<br>• Pump and water turbine designs<br>• Design examples of reciprocating engines and turbomachinery<br>• Steam power plants<br>• Gas turbine systems. |
| **Literature** | • Kalide: Kraft- und Arbeitsmaschinen<br>• Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985<br>• Strauß, K.: Kraftwerkstechnik. Springer-Verlag, 2006<br>• Kugeler und Phlippen: Energietechnik. Springer-Verlag, 1990<br>• Bohn, T. (Hrsg.): Handbuchreihe Energie, Band 7: Gasturbinenkraftwerke, Kombikraftwerke, Heizkraftwerke und Industriekraftwerke, Technischer Verlag Resch / Verlag TÜV Rheinland |

| **Course L0210: Gas and Steam Power Plants** | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Lars Wiese, Dr. Stylianos Rafailidis |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | In the 1st part of the lecture a general introduction into fluid-flow machines and steam power plants is offered, including:<br>• Energy balance of a fluid-flow machine<br>• Theory of turbine and compressor stage<br>• Equal and positive pressure blading<br>• Flow losses<br>• Characteristic numbers<br>• Axial and radial design<br>• Design features<br>• Hydraulic fluid-flow machines<br>• Pump and water turbine designs<br>• Design examples of reciprocating engines and turbomachinery<br>• Steam power plants<br>• Gas turbine systems<br>• Diesel engine systems<br>• Waste heat utilisation<br>followed by the more specialised issues:<br>• Electricity Demand and Forecasting<br>• Thermodynamic fundamentals<br>• Energy Conversion in Thermal Power Plants<br>• Types of Power Plant<br>• Layout of the power plant block<br>• Individual elements of the power plant<br>• Cooling systems<br>• Flue gas cleaning<br>• Operation characteristics of the power plant<br>• Construction materials<br>• Location of power plants<br>The environmental impact of acidification, fine particulate or $CO_2$ emissions and the resulting climatic effects are a special focus of the lecture and the lecture hall exercise. The challenges in plant operation from interconnecting conventional power plants and renewable energy sources are discussed and the technical options for providing security of supply and network stability are presented, also under consideration of cost effectiveness. In this critical review, focus is especially placed on the compatibility of the different solutions with the environment and climate. With this, the awareness for the responsibility of an engineer's own actions are emphasized and the potential extent of the different solutions presented clearly.<br>Within the framework of the exercise the students learn the use of the specialised software suite EBSILON Professional ™. With this tool small tasks are solved on the PC, to highlight aspects of the design and development of power plant cycles. The students present their results orally and can afterwards ask questions and get feedback. The course work has a positive effect on the students final grade. |
| **Literature** | • Skripte<br>• Kalide: Kraft- und Arbeitsmaschinen<br>• Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985<br>• Strauß, K.: Kraftwerkstechnik. Springer-Verlag, 2006<br>• Kugeler und Phlippen: Energietechnik. Springer-Verlag, 1990<br>• T . Bohn (Hrsg.): Handbuchreihe Energie, Band 7: Gasturbinenkraftwerke, Kombikraftwerke, Heizkraftwerke und Industriekraftwerke, Technischer Verlag Resch / Verlag TÜV Rheinland |

## Module M0610: Electrical Machines and Actuators

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Electrical Machines and Actuators (L0293) | Lecture | 3 | 4 |
| Electrical Machines and Actuators (L0294) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Thorsten Kern |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of mathematics, in particular complexe numbers, integrals, differentials<br><br>Basics of electrical engineering and mechanical engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can to draw and explain the basic principles of electric and magnetic fields.<br><br>They can describe the function of the standard types of electric machines and present the corresponding equations and characteristic curves. For typically used drives they can explain the major parameters of the energy efficiency of the whole system from the power grid to the driven engine. |
| *Skills* | Students are able to calculate two-dimensional electric and magnetic fields in particular ferromagnetic circuits with air gap. For this they apply the usual methods of the design auf electric machines.<br><br>They can calulate the operational performance of electric machines from their given characteristic data and selected quantities and characteristic curves. They apply the usual equivalent circuits and graphical methods. |
| **Personal Competence** | |
| *Social Competence* | none |
| *Autonomy* | Students are able independently to calculate electric and magnatic fields for applications. They are able to analyse independently the operational performance of electric machines from the charactersitic data and theycan calculate thereof selected quantities and characteristic curves. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Design of four machines and actuators, review of design files |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Engineering Science: Specialisation Electrical Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Elective Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory |

| Course L0293: Electrical Machines and Actuators | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Thorsten Kern, Dennis Kähler |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Electric field: Coulomb´s law, flux (field) line, work, potential, capacitor, energy, force, capacitive actuators<br><br>Magnetic field: force, flux line, Ampere´s law, field at bounderies, flux, magnetic circuit, hysteresis, induction, self-induction, mutual inductance, transformer, electromagnetic actuators<br><br>Synchronous machines, construction and layout, equivalent single line diagrams, no-load and short-cuircuit characteristics, vector diagrams, motor and generator operation, stepper motors<br><br>DC-Machines: Construction and layout, torque generation mechanismen, torque vs speed characteristics, commutation,<br><br>Asynchronous Machines. Magnetic field, construction and layout, equivalent single line diagram, complex stator current diagram (Heylands´diagram), torque vs. speed characteristics, rotor layout (squirrel-cage vs. sliprings),<br><br>Drives with variable speed, inverter fed operation, special drives |
| **Literature** | Hermann Linse, Roland Fischer: "Elektrotechnik für Maschinenbauer", Vieweg-Verlag; Signatur der Bibliothek der TUHH: ETB 313<br><br>Ralf Kories, Heinz Schmitt-Walter: "Taschenbuch der Elektrotechnik"; Verlag Harri Deutsch; Signatur der Bibliothek der TUHH: ETB 122<br><br>"Grundlagen der Elektrotechnik" - anderer Autoren<br><br>Fachbücher "Elektrische Maschinen" |

| Course L0294: Electrical Machines and Actuators | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Kern, Dennis Kähler |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0725: Production Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Production Engineering I (L0608) | Lecture | 2 | 2 |
| Production Engineering I (L0612) | Recitation Section (large) | 1 | 1 |
| Production Engineering II (L0610) | Lecture | 2 | 2 |
| Production Engineering II (L0611) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Jan Hendrik Dege |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | no course assessments required<br><br>internship recommended |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to ...<br><br>• name basic criteria for the selection of manufacturing processes.<br>• name the main groups of Manufacturing Technology.<br>• name the application areas of different manufacturing processes.<br>• name boundaries, advantages and disadvantages of the different manufacturing process.<br>• describe elements, geometric properties and kinematic variables and requirements for tools, workpiece and process.<br>• explain the essential models of manufacturing technology. |
| *Skills* | Students are able to...<br><br>• select manufacturing processes in accordance with the requirements.<br>• design manufacturing processes for simple tasks to meet the required tolerances of the component to be produced.<br>• assess components in terms of their production-oriented construction. |
| **Personal Competence** | |
| *Social Competence* | Students are able to ...<br><br>• develop solutions in a production environment with qualified personnel at technical level and represent decisions. |
| *Autonomy* | Students are able to ..<br><br>• interpret independently the manufacturing process.<br>• assess own strengths and weaknesses in general.<br>• assess their learning progress and define gaps to be improved.<br>• assess possible consequences of their actions. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Elective Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Elective Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Compulsory |

| Course L0608: Production Engineering I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jan Hendrik Dege |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Manufacturing Accuracy<br>• Manufacturing Metrology<br>• Measurement Errors and Uncertainties<br>• Introduction to Forming<br>• Massiv forming and Sheet Metal Forming<br>• Introduction to Machining Technology<br>• Geometrically defined machining (Turning, milling, drilling, broaching, planning) |
| **Literature** | Dubbel, Heinrich (Grote, Karl-Heinrich.; Feldhusen, Jörg.; Dietz, Peter,; Ziegmann, Gerhard,;) Taschenbuch für den Maschinenbau : mit Tabellen. Berlin [u.a.] : Springer, 2007<br><br>Fritz, Alfred Herbert: Fertigungstechnik : mit 62 Tabellen. Berlin [u.a.] : Springer, 2004<br><br>Keferstein, Claus P (Dutschke, Wolfgang,;): Fertigungsmesstechnik : praxisorientierte Grundlagen, moderne Messverfahren. Wiesbaden : Teubner, 2008<br><br>Mohr, Richard: Statistik für Ingenieure und Naturwissenschaftler : Grundlagen und Anwendung statistischer Verfahren. Renningen : expert-Verl, 2008<br><br>Klocke, F., König, W.: Fertigungsverfahren Bd. 1 Drehen, Fäsen, Bohren. 8. Aufl., Springer (2008)<br><br>Klocke, Fritz (König, Wilfried,;): Umformen. Berlin [u.a.] : Springer, 2006<br><br>Paucksch, E.: Zerspantechnik, Vieweg-Verlag, 1996<br><br>Tönshoff, H.K.; Denkena, B., Spanen. Grundlagen, Springer-Verlag (2004) |

| Course L0612: Production Engineering I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Jan Hendrik Dege |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0610: Production Engineering II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jan Hendrik Dege, Dr. Dirk Herzog, Prof. Claus Emmelmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Geometrically undefined machining (grinding, lapping, honing)<br>• Introduction into erosion technology<br>• Introduction into blastig processes<br>• Introduction to the manufacturing process forming (Casting, Powder Metallurgy, Composites)<br>• Fundamentals of Laser Technology<br>• Process versions and Fundamentals of Laser Joining Technology |
| **Literature** | Klocke, F., König, W.: Fertigungsverfahren Bd. 2 Schleifen, Honen, Läppen, 4. Aufl., Springer (2005)<br><br>Klocke, F., König, W.: Fertigungsverfahren Bd. 3 Abtragen, Generieren und Lasermaterialbearbeitung. 4. Aufl., Springer (2007)<br><br>Spur, Günter (Stöferle, Theodor.;): Urformen. München [u.a.] : Hanser, 1981<br><br>Schatt, Werner (Wieters, Klaus-Peter,; Kieback, Bernd,;): Pulvermetallurgie : Technologien und Werkstoffe. Berlin [u.a.] : Springer, 2007 |

| Course L0611: Production Engineering II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Jan Hendrik Dege, Dr. Dirk Herzog, Prof. Claus Emmelmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0829: Foundations of Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Management Tutorial (L0882) | Recitation Section (small) | 2 | 3 |
| Introduction to Management (L0880) | Lecture | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Christian Lüthje |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic Knowledge of Mathematics and Business |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After taking this module, students know the important basics of many different areas in Business and Management, from Planning and Organisation to Marketing and Innovation, and also to Investment and Controlling. In particular they are able to<br>• explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management<br>• explain the most important aspects of and goals in Management and name the most important aspects of entreprneurial projects<br>• describe and explain basic business functions as production, procurement and sourcing, supply chain management, organization and human ressource management, information management, innovation management and marketing<br>• explain the relevance of planning and decision making in Business, esp. in situations under multiple objectives and uncertainty, and explain some basic methods from mathematical Finance<br>• state basics from accounting and costing and selected controlling methods. |
| *Skills* | Students are able to analyse business units with respect to different criteria (organization, objectives, strategies etc.) and to carry out an Entrepreneurship project in a team. In particular, they are able to<br>• analyse Management goals and structure them appropriately<br>• analyse organisational and staff structures of companies<br>• apply methods for decision making under multiple objectives, under uncertainty and under risk<br>• analyse production and procurement systems and Business information systems<br>• analyse and apply basic methods of marketing<br>• select and apply basic methods from mathematical finance to predefined problems<br>• apply basic methods from accounting, costing and controlling to predefined problems |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• work successfully in a team of students<br>• to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project<br>• to communicate appropriately and<br>• to cooperate respectfully with their fellow students. |
| *Autonomy* | Students are able to<br>• work in a team and to organize the team themselves<br>• to write a report on their project. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | several written exams during the semester plus final test (90 minutes) |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Specialisation Biomechanics: Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Compulsory |

| | |
|---|---|
| | Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory<br>Mechanical Engineering: Specialisation Product Development and Production: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| **Course L0882: Management Tutorial** | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Lüthje, Katharina Roedelius |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | In the management tutorial, the contents of the lecture will be deepened by practical examples and the application of the discussed tools.<br><br>If there is adequate demand, a problem-oriented tutorial will be offered in parallel, which students can choose alternatively. Here, students work in groups on se selected projects that focus on the elaboration of an innovative business idea from the point of view of an established company or a startup. Again, the busin knowledge from the lecture should come to practical use. The group projects are guided by a mentor. |
| **Literature** | Relevante Literatur aus der korrespondierenden Vorlesung. |

| Course L0880: Introduction to Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Matthias Meyer, Prof. Christian Lüthje, Prof. Christian Ringle, Prof. Christian Thies, Prof. Christoph Ihl, Prof. Kathrin Fischer, Prof. Moritz Göldner, Prof. Thomas Wrona, Prof. Thorsten Blecker, Prof. Tim Schweisfurth, Prof. Wolfgang Kersten |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | • Introduction to Business and Management, Business versus Economics, relevant areas in Business and Management<br>• Important definitions from Management,<br>• Developing Objectives for Business, and their relation to important Business functions<br>• Business Functions: Functions of the Value Chain, e.g. Production and Procurement, Supply Chain Management, Innovation Management, Marketing and Sales<br>Cross-sectional Functions, e.g. Organisation, Human Ressource Management, Supply Chain Management, Information Management<br>• Definitions as information, information systems, aspects of data security and strategic information systems<br>• Definition and Relevance of innovations, e.g. innovation opporunities, risks etc.<br>• Relevance of marketing, B2B vs. B2C-Marketing<br>• different techniques from the field of marketing (e.g. scenario technique), pricing strategies<br>• important organizational structures<br>• basics of human ressource management<br>• Introduction to Business Planning and the steps of a planning process<br>• Decision Analysis: Elements of decision problems and methods for solving decision problems<br>• Selected Planning Tasks, e.g. Investment and Financial Decisions<br>• Introduction to Accounting: Accounting, Balance-Sheets, Costing<br>• Relevance of Controlling and selected Controlling methods<br>• Important aspects of Entrepreneurship projects |
| **Literature** | Bamberg, G., Coenenberg, A.: Betriebswirtschaftliche Entscheidungslehre, 14. Aufl., München 2008<br><br>Eisenführ, F., Weber, M.: Rationales Entscheiden, 4. Aufl., Berlin et al. 2003<br><br>Heinhold, M.: Buchführung in Fallbeispielen, 10. Aufl., Stuttgart 2006.<br><br>Kruschwitz, L.: Finanzmathematik. 3. Auflage, München 2001.<br><br>Pellens, B., Fülbier, R. U., Gassen, J., Sellhorn, T.: Internationale Rechnungslegung, 7. Aufl., Stuttgart 2008.<br><br>Schweitzer, M.: Planung und Steuerung, in: Bea/Friedl/Schweitzer: Allgemeine Betriebswirtschaftslehre, Bd. 2: Führung, 9. Aufl., Stuttgart 2005.<br><br>Weber, J., Schäffer, U. : Einführung in das Controlling, 12. Auflage, Stuttgart 2008.<br><br>Weber, J./Weißenberger, B.: Einführung in das Rechnungswesen, 7. Auflage, Stuttgart 2006. |

## Specialization Maritime Technologies

### Module M0659: Fundamentals of Ship Structural Design and Analysis

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Ship Structural Design (L0411) | Lecture | 2 | 2 |
| Fundamentals of Ship Structural Design (L0413) | Recitation Section (small) | 1 | 2 |
| Fundamentals of Ship Structural Analysis (L0410) | Lecture | 2 | 2 |
| Fundamentals of Ship Structural Analysis (L0414) | Recitation Section (small) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Sören Ehlers |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mechanics I - III<br>Fundamentals of Materials Science I - III<br>Welding Technology I<br>Fundamentals of Mechanical Design I - III |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can reproduce the basic contents of the structural behaviour of ship structures; they can explain the theory and methods for the calculation of deformations and stresses in beam-like structures.<br>Furthermore, they can reproduce the basis contents of codes (rules), materials, semi-finished products, joining and principles of structural design of components in the ship structure. |
| *Skills* | Students are capable of applying the methods and tools for the calculation of linear deformations and stresses in the above mentioned structures; they can choose calculation models of typical ship structures.<br>Furthermore, they are capable to apply the methods of drawing and sizing the ship structure; they can select suitable materials, semi-finished products and joints. |
| **Personal Competence** | |
| *Social Competence* | The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry. |
| *Autonomy* | The students are capable to independently idealize real ship structures and to select suitable methods for analysis of beam-like structures; they are capable to assess the results of structural analyses.<br>Furthermore, they are capable to assess drawings of complex ship structures and to design ship structures for various requirements and boundary conditions. |
| **Workload in Hours** | Independent Study Time 156, Study Time in Lecture 84 |
| **Credit points** | 8 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 3 hours |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory |

| Course L0411: Fundamentals of Ship Structural Design | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Rüdiger Ulrich Franz von Bock und Polach |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Chapters:<br>1. Introduction<br>3. Class societies and their tasks<br>4. Materials for steel shipbuilding<br>5. Welding and Cutting<br>6. Semi-finished products in steel shipbuilding<br>7. Determining the scantlings for local loads<br>8. Longitudinal strength of the hull girder<br>9. Determining the scantlings of longitudinal structural members<br>10. Determining the scantlings of bottom and side structures<br>11. Decks and Hatch Openings<br>12. Effective breadth<br>13. Iterative determination of scantlings (POSEIDON) |
| **Literature** | Vorlesungsskript mit weiteren Literaturangaben wird über das Internet verfügbar gemacht |

| Course L0413: Fundamentals of Ship Structural Design | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Dr. Rüdiger Ulrich Franz von Bock und Polach |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Chapters:<br>1. Introduction<br>3. Class societies and their tasks<br>4. Materials for steel shipbuilding<br>5. Welding and Cutting<br>6. Semi-finished products in steel shipbuilding<br>7. Determining the scantlings for local loads<br>8. Longitudinal strength of the hull girder<br>9. Determining the scantlings of longitudinal structural members<br>10. Determining the scantlings of bottom and side structures<br>11. Decks and Hatch Openings<br>12. Effective breadth<br>13. Iterative determination of scantlings (POSEIDON) |
| **Literature** | Vorlesungsskript mit weiteren Literaturangaben wird über das Internet verfügbar gemacht |

| Course L0410: Fundamentals of Ship Structural Analysis | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Contents:<br>1. Introduction<br>2. Finite element method (f.e. method) by the example of trussworks<br>3. Force methods for frameworks<br>4. F.e. method for frameworks<br>5. Shear and torsion in thin-walled beams<br>6. Beams subjected to longitudinal forces |
| **Literature** | Vorlesungsskript mit weiteren Literaturangaben; div. Bücher über die Methode der finiten Elemente |

| Course L0414: Fundamentals of Ship Structural Analysis | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Contents:<br>1. Introduction<br>2. Finite element method (f.e. method) by the example of trussworks<br>3. Force methods for frameworks<br>4. F.e. method for frameworks<br>5. Shear and torsion in thin-walled beams<br>6. Beams subjected to longitudinal forces |
| **Literature** | Vorlesungsskript mit weiteren Literaturangaben; div. Bücher über die Methode der finiten Elemente |

## Module M1914: Fundamentals of renewable ocean utilization

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of renewable ocean utilization (L3158) | Lecture | 3 | 3 |
| Fundamentals of renewable ocean utilization (L3159) | Recitation Section (small) | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Moustafa Abdel-Maksoud |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students understand the fundamentals of ocean engineering necessary to design and evaluate maritime structures used for renewable ocean utilization:<br>-Introduction to oceanography<br>-Linear wave theory<br>-Introduction to nonlinear ocean waves<br>-Hydrostatics and hydrodynamics of floating bodies in ocean waves<br>-Computation of wave-induced loads<br>-Mooring<br>-Fundamentals of mechanical strength and structural dynamics<br>-Introduction to numerical computation of maritime problems |
| *Skills* | Students can apply the learned theoretical knowledge to explain the fundamentals of renewable ocean utilization and can solve related computational tasks. |
| **Personal Competence** | |
| *Social Competence* | Students can participate in discussions regarding the fundamentals of renewable ocean utilization. |
| *Autonomy* | Students can independently exploit sources with respect to the emphasis of the lectures. They can choose and aquire the for the particular task useful knowledge. Furthermore, they can solve computational tasks of approaches concerning the fundamentals of renewable ocean utilization independently with the assistance of the lecture. Regarding to this they can assess their specific learning level and can consequently define the further workflow. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>No / 10 % / Presentation |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Compulsory |

### Course L3158: Fundamentals of renewable ocean utilization

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Moustafa Abdel-Maksoud, Dr. Robinson Peric, Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

### Course L3159: Fundamentals of renewable ocean utilization

| | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Moustafa Abdel-Maksoud, Dr. Robinson Peric, Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

## Module M0933: Fundamentals of Materials Science

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Materials Science I (L1085) | Lecture | 2 | 2 |
| Fundamentals of Materials Science II (Advanced Ceramic Materials, Polymers and Composites) (L0506) | Lecture | 2 | 2 |
| Physical and Chemical Basics of Materials Science (L1095) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Jörg Weißmüller |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Highschool-level physics, chemistry und mathematics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students have acquired a fundamental knowledge on metals, ceramics and polymers and can describe this knowledge comprehensively. Fundamental knowledge here means specifically the issues of atomic structure, microstructure, phase diagrams, phase transformations, corrosion and mechanical properties. The students know about the key aspects of characterization methods for materials and can identify relevant approaches for characterizing specific properties. They are able to trace materials phenomena back to the underlying physical and chemical laws of nature. |
| *Skills* | The students are able to trace materials phenomena back to the underlying physical and chemical laws of nature. Materials phenomena here refers to mechanical properties such as strength, ductility, and stiffness, chemical properties such as corrosion resistance, and to phase transformations such as solidification, precipitation, or melting. The students can explain the relation between processing conditions and the materials microstructure, and they can account for the impact of microstructure on the material's behavior. |
| **Personal Competence** | |
| *Social Competence* | - |
| *Autonomy* | - |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>Data Science: Specialisation II. Application: Elective Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory |

### Course L1085: Fundamentals of Materials Science I

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jörg Weißmüller |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | Vorlesungsskript<br><br>W.D. Callister: Materials Science and Engineering - An Introduction. 5th ed., John Wiley & Sons, Inc., New York, 2000, ISBN 0-471-32013-7<br><br>P. Haasen: Physikalische Metallkunde. Springer 1994 |

| Course L0506: Fundamentals of Materials Science II (Advanced Ceramic Materials, Polymers and Composites) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Bodo Fiedler, Prof. Gerold Schneider |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Chemische Bindungen und Aufbau von Festkörpern; Kristallaufbau; Werkstoffprüfung; Schweißbarkeit; Herstellung von Keramiken; Aufbau und Eigenschaften der Keramik; Herstellung, Aufbau und Eigenschaften von Gläsern; Polymerwerkstoffe, Makromolekularer Aufbau; Struktur und Eigenschaften der Polymere; Polymerverarbeitung; Verbundwerkstoffe |
| **Literature** | Vorlesungsskript<br><br>W.D. Callister: Materials Science and Engineering -An Introduction-5th ed., John Wiley & Sons, Inc., New York, 2000, ISBN 0-471-32013-7 |

| Course L1095: Physical and Chemical Basics of Materials Science | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Gregor Vonbun-Feldbauer |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Motivation: „Atoms in Mechanical Engineering?“<br>• Basics: Force and Energy<br>• The electromagnetic Interaction<br>• „Detour“: Mathematics (complex e-funktion etc.)<br>• The atom: Bohr's model of the atom<br>• Chemical bounds<br>• The multi part problem: Solutions and strategies<br>• Descriptions of using statistical thermodynamics<br>• Elastic theory of atoms<br>• Consequences of atomar properties on makroskopic Properties: Discussion of examples (metals, semiconductors, hybrid systems) |
| **Literature** | Für den **Elektromagnetismus:**<br>• Bergmann-Schäfer: „Lehrbuch der Experimentalphysik“, Band 2: „Elektromagnetismus“, de Gruyter<br>Für die **Atomphysik:**<br>• Haken, Wolf: „Atom- und Quantenphysik“, Springer<br>Für die **Materialphysik und Elastizität:**<br>• Hornbogen, Warlimont: „Metallkunde“, Springer |

## Module M1912: Green maritime energy conversion

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Green maritime energy conversion (L3154) | Lecture | 4 | 4 |
| Green maritime energy conversion (L3155) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Christopher Friedrich Wirz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | None |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students understand the fundamentals of green maritime energy conversion. |
| *Skills* | Students can apply the learned theoretical knowledge to explain fundamental relationships regarding the different approaches for green maritime energy conversion and can solve related computational tasks. |
| **Personal Competence** | |
| *Social Competence* | Students can participate in discussions about the challenges and options regarding maritime energy conversion in a technical, societal and political context. |
| *Autonomy* | Students can independently exploit sources with respect to the emphasis of the lectures. They can choose and aquire the for the particular task useful knowledge. Furthermore, they can solve computational tasks of approaches for green maritime energy independently with the assistance of the lecture. Regarding to this they can assess their specific learning level and can consequently define the further workflow. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Compulsory |

### Course L3154: Green maritime energy conversion

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Lecturer** | Prof. Christopher Friedrich Wirz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

### Course L3155: Green maritime energy conversion

| | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christopher Friedrich Wirz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

## Module M1913: Green maritime resources

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Green maritime resources (L3156) | Lecture | 3 | 3 |
| Green maritime resources (L3157) | Recitation Section (small) | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Moustafa Abdel-Maksoud |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students have an overview on approaches to extract energy from the oceans. |
| *Skills* | Students can apply the learned theoretical knowledge to give an overview over green maritime resources and can solve related computational tasks. |
| **Personal Competence** | |
| *Social Competence* | Students can participate in discussions regarding green maritime resources. |
| *Autonomy* | Students can independently exploit sources with respect to the emphasis of the lectures. They can choose and aquire the for the particular task useful knowledge. Furthermore, they can solve computational tasks of approaches concerning green maritime resources independently with the assistance of the lecture. Regarding to this they can assess their specific learning level and can consequently define the further workflow. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**: No / 10 % / Presentation |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Compulsory |

### Course L3156: Green maritime resources

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Dr. Robinson Peric |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

### Course L3157: Green maritime resources

| | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Dr. Robinson Peric |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

## Module M1118: Hydrostatics and Body Plan

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Hydrostatics (L1260) | Lecture | 2 | 3 |
| Hydrostatics (L1261) | Recitation Section (large) | 2 | 1 |
| Body Plan (L1452) | Project Seminar | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Stefan Krüger |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Good knowledge in Mathemathics I-III and Mechanics I-III.<br>It is recommended that the students are familiar with typical design relevant drawings, e.g. Body Plan, GA- Plan, Tank Plan etc. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The lecture enables the student to carry out all necessary theoretical calculations for ship design on a scientific level. The lecture is basic requirement for all following lectures in the subjects ship design and safety of ships.<br>The following topics are discussed during the lecture:<br>1. Numerical diffrentiation and integration<br>2. Equilibrium floating conditions<br>3. Stability of Equilibrium floating conditions, righting levers<br>4. Hydrostatics for small inclinations, Metacentric height, hydrostatical Stiffness Matrix<br>5. Heeling Moments and righting lever balances<br>6. Stability in waves<br>7. Damage stability assessment<br>8. Launching, docking, grounding |
| *Skills* | The student is able to carry out hydrostatic calculations to ensure that the ship has sufficient stability. He is able to design hull forms that are safe against capsizing or sinking. |
| **Personal Competence** | |
| *Social Competence* | he student gets access to hydrostatics that he is able to persuade his building supervision team. |
| *Autonomy* | The student gets access to hydrostatics that he is able to discuss hydrostatical problems during his work at a shipyard. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Naval Architecture: Core Qualification: Compulsory |

### Course L1260: Hydrostatics

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Stefan Krüger |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Numerical Integration, Diffrentation, Interpolation<br>- Trapezoidal Rule, Simpson, Tschebyscheff, graphical Integration Methods<br>- Determination of Areas, 1st and 2nd order Moments<br>- Numerical Diffrentation, Spline Interpolation<br>2. Buyoancy<br>- Principle of Archimedes<br>- Equlibrium Floating Condition<br>- Equlibrium Computations<br>- Hydrostatic Tables and Sounding Tables<br>- Trim Tables |

3. Stability at large heeling angles

- Stability Equation
- Cross Curves of Stability and Righting Levers
- Numerical and Graphical Determination of Cross Curves
- Heeling Moments of Free Surfaces, Water on Deck, Water Ingress
- Heeling Moments of Different Type
- Balance of Heeling and Righting Moments acc. to BV 1030
- Intact Stability Code (General Critaria)

4. Linearization of Stability Problems

- Linearization of Restoring Forces and Moments
- Correlation between Metacentric Height and Righting Lever at small heeling angles
- Computation of Path of Metacentric Height for Modern Hull Forms
- Correlation between Righting Lever and Path of Metacentric Height
- Hydrostatic Stiffness Matrix
- Definition of MCT
- Computation of Equilibrum Floating Conditions from Hydrostatic Tables
- Effect of Free Surfaces on Initial GM
- Roll Motions at Small Roll Angles

6. Stability in Waves

- Roll Motions at Large Amplitudes
- Pure Loss of Stability on the Wave Crest
- Principle of Parametric Excitation
- Principle of Direct Wave Moments
- Grim´s Equivalent Wave Concept

6 Longitudinal Strength

- Longitudinal Mass Distribution, Shear Forces, Bending Moments
- Longitudinal Strength in Stability Booklet

7. Deadweight Survey and Inclining Experiment

- Deplacement Computations from Draft mark Readings
- Weights to go on /come from board
- Inclining Experiment with Heeling Moments from Weights and Heeling Tanks
- Residual Sounding Volumes
- Determination of COG from Metacentric height and from Cross Curves
- Roll Decay Test

8. Launching and Docking

- Launching Plan, Arrangement of Launching Blocks
- Rigid Body Launching: Tilting, Dumping, Equation of Techel
- Computation of Launching Event
- Bottom Pressure and Longitudinal Strength
- Linear- Elastic Effects
- Transversal Stability on Slipway and in Dock

9. Grounding

- Loss of Buoynacy when Grounded
- Pointwise Grounding
- Ship Grounds on Keel

10. Introduction into Damage Stability Problems

- Added Mass Method
- Loss of Buoyant Volume Method

| | |
|---|---|
| | - Simple Equilibrium Computations<br>- Intermediate Stages of Flooding (Addes Mass Method), Cross- and Downflooding<br>- Water Ingress Through Openings<br>11. Special Problems (optional and agreed upon)<br>- e.g. Heavy Lift Operations<br>- e.g. Jacking of Jackup Vessels<br>- e.g. Sinking After Water Ingress |
| **Literature** | 1. Herner/Rusch: Die Theorie des Schiffes<br>Fachbuchverlag Leipzig<br><br>2. Henschke<br>Schiffstechnisches Handbuch, Band 1<br>VEB Technik Verlag Berlin<br><br>3. Das Skript zur Vorlesung, Anwendungsbeispiele und Klausuren sind auf unserer Homepage abrufbar. |

| **Course L1261: Hydrostatics** | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Stefan Krüger |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| **Course L1452: Body Plan** | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Stefan Krüger |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | As preparation for the lecture “Hydrostatics”, the students must develop a body plan of a modern twin screw vessel (cruise liner, RoPAx- feryy, RoRo ) and perform elementary volumetric computations. The body plan is to be developed from a given GA or can be designed freely. All computations shall be based on graphical integration methods. The body plan consists of :<br>- Grid<br>- approx. 20 sections, 5 Waterlines, 5 Buttocks<br>- Computation Volume and centre of buoyancy for several drafts<br>- Computation of Righting Lever curve for a given displacement based on and graphical integration for several heeling angles. |
| **Literature** | 1. Herner/Rusch: Die Theorie des Schiffes<br>Fachbuchverlag Leipzig<br><br>2. Henschke<br>Schiffstechnisches Handbuch, Band 1<br>VEB Technik Verlag Berlin<br><br>3. Das Skript zur Vorlesung, Anwendungsbeispiele und Klausuren sind auf unserer Homepage abrufbar. |

## Module M0655: Computational Fluid Dynamics I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Computational Fluid Dynamics I (L0235) | Lecture | 2 | 3 |
| Computational Fluid Dynamics I (L0419) | Recitation Section (large) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Thomas Rung |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Students should have sound knowledge of engineering mathematics (series expansions, internal & vector calculus), and be familiar with the foundations of partial/ordinary differential equations. They should also be familiar with engineering fluid mechanics and thermodynamics. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will have the required combined knowledge of thermo-/fluid dynamics and numerical analysis to translate general principles of thermo-/fluid engineering into discrete algorithms on the basis of local (finite differences/volumes) and global (potential theory) ansatz functions. They are familiar with the similarities and differences between different discretisation and approximation concepts for investigating coupled systems of non-linear, convective partial differential equations (PDE), and explain the motivation for applying them. Students have the required background knowledge to develop, code, explain and apply numerical algorithms dedicated to the solution of thermofluid dynamic PDEs. They are familiar with most numerical methods used to predict thermofluid dynamic fields, in particular their realms and limitations. |
| *Skills* | The students are able choose and apply appropriate numerical procedures that integrate the governing thermofluid dynamic PDEs in space and time. They can apply/optimise numerical analysis concepts to/for fluid dynamic applications. They can code computational algorithms in a structured way, apply these codes for parameter investigations and supplement interfaces to extract simulation data for an engineering analysis. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss problems, present the results of their own analysis, and jointly develop, implement and report on solution strategies that address given technical reference problems. |
| *Autonomy* | The students can independently analyse numerical methods to solving fluid engineering problems. They are able to critically analyse own results as well as external data with regards to the plausibility and reliability. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 2h |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L0235: Computational Fluid Dynamics I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thomas Rung |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Fundamentals of computational modelling of thermofluid dynamic problems. Development of numerical algorithms.<br>1. Partial differential equations<br>2. Foundations of finite numerical approximations<br>3. Computation of potential flows<br>4. Introduction of finite-differences<br>5. Approximation of convective, diffusive and transient transport processes<br>6. Formulation of boundary conditions and initial conditions<br>7. Assembly and solution of algebraic equation systems<br>8. Facets of weighted -residual approaches<br>9. Finite volume methods<br>10. Basics of grid generation |
| **Literature** | Ferziger and Peric: *Computational Methods for Fluid Dynamics*, Springer |

| Course L0419: Computational Fluid Dynamics I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thomas Rung |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1804: Engineering Mechanics III (Dynamics)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Engineering Mechanics III (Dynamics) (L1134) | Lecture | 3 | 3 |
| Engineering Mechanics III (Dynamics) (L1136) | Recitation Section (large) | 1 | 1 |
| Engineering Mechanics III (Dynamics) (L1135) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Robert Seifried |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I, II, Engineering Mechanics I (Statics). Parallel to Engineering Mechanik III the module Mathematics III should be attended. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can<br>• describe the axiomatic procedure used in mechanical contexts;<br>• explain important steps in model design;<br>• present technical knowledge in kinematics, kinetics and vibrations. |
| *Skills* | The students can<br>• explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems;<br>• apply basic kinematic, kinetic and vibraton methods to engineering problems;<br>• estimate the reach and boundaries of kinematic, kinetic and vibraton methods and extend them to be applicable to wider problem sets. |
| **Personal Competence** | |
| *Social Competence* | The students can work in groups and support each other to overcome difficulties. |
| *Autonomy* | Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: No; Bonus: 20 %; Form: Midterm; Description: Midterm |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L1134: Engineering Mechanics III (Dynamics) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Robert Seifried |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Kinematics<br>1.1 Motion of a particle<br>1.2 Planar motion of a rigid body<br>1.3 Spatial motion of a rigid body<br>1.4 Spatial relative Kinematics<br><br>2 Kinetics<br>2.1 Linear momentum and change of linear momentum<br><br>2.2 Angular momentum and change of angular momentum<br>2.3 Kinetics of rigid bodies<br>2.4 Energy and balance of energy<br><br>3 Vibrations<br>3.1 Classification of Vibrations<br>3.2 Free undamped vibration<br>3.3 Free damped vibration<br>3.4 Forced vibration<br><br>4. Impact problems<br><br>5 Kinetics of gyroscopes<br>5.1 Free gyroscopic motion<br>5.2 Forced gyroscopic motion |
| **Literature** | K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009).<br>D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 3 und 4. 11. Auflage, Springer (2011). |

| Course L1136: Engineering Mechanics III (Dynamics) | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Robert Seifried |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1135: Engineering Mechanics III (Dynamics) | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Robert Seifried |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1713: Green Technologies III

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Study Work Green Technologies (L2766) | Project Seminar | 2 | 4 |
| Scientific Work and Writing (L2765) | Seminar | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Dozenten des Studiengangs |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | keine |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students, based on a literature survey, learn to study in detail a subject theme from the disciplines of green technologies and deliver afterwards a summary presentation to a specialised audience. Environmental issues and their multidisciplinary linkages are preferred, when selecting the thematic area of these studies. Through their own written contribution the students communicate an overview over the subject and practice technical writing. With the discussion the students practice scientific debating on a specialised subject matter. |
| *Skills* | The students can, when working on a technical topic not familiar to them:<br>• conduct a literature survey<br>• choose the relevant information for their presentation<br>• prepare a written summary<br>• present results in front of peers and staff<br>• correctly cite and reference sources. |
| **Personal Competence** | |
| *Social Competence* | The students practice a critical assessment of the literature in a predefined specialised theme and learn to give presentations on their own technical sub-topic tailored to their public and discuss with the audience. When attending technical presentations, the students can formulate questions to other speakers and participate in the ensuing discussion.<br>The fulfilment of the tasks combines independent work with group and teamwork. |
| *Autonomy* | The students can, guided by instructors, critically reflect on their learning and work status, and write a scientific report. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Study work |
| **Examination duration and scale** | - |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory |

### Course L2766: Study Work Green Technologies

| | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Studiengangs |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Students carry out a research project in a scientific field under the guidance of an academic staff member. For this purpose, the student can approach the staff of the respective institute and discuss a topic. The topic is then worked on within 4 weeks and regular consultations are held with the supervisor. The student research project should be the size of a scientific article and must be presented to the lecturer after completion as part of a presentation (approx. 15 minutes). |
| **Literature** | |

| Course L2765: Scientific Work and Writing | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Studiengangs, Dr. Detlev Bieler, Florian Hagen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The seminar offers an introduction into the diverse aspects of academic research and writing: Finding the topic, finding specialized information, knowledge organisation, writing, presenting and publishing. Suggestions for reflecting own processes of learning, informing and writing - in addition to practical recommendations and tips - facilitate the start and the creation of bachelor and master theses, works, which bring thoroughly self-fulfillment and make fun.<br><br>Topics of the seminar will be in particular<br><br>• Scientific scholarship and academic research methods:<br>• Introduction, organization, attributes of science:<br>How is scientific knowledge created?<br>Work scheduling, finding topics, time management, specialities of academic research in engineering<br>• Finding specialized information: Full texts and library resources, databases http://www.tub.tuhh.de/en/subject-information/informing-points-to-survive/<br>• Reference management: http://www.tub.tuhh.de/en/publishing/reference-management/<br>Knowledge organisation and creating publications with Citavi<br>• Citing correctly and avoiding plagiarism<br>• Preparing and doing presentations |
| **Literature** | 1. Semesterapparat "Wissenschaftliches Arbeiten" in der TU-Bibliothek: http://tinyurl.com/Semesterapparat-Wiss-Arbeiten<br>2. Weblog Wissenschaftliches Arbeiten der TU-Bibliothek: https://www.tub.tuhh.de/wissenschaftliches-arbeiten/<br>3. Online-Tutorial VISION der TU-Bibliothek zum wissenschaftlichen Arbeiten: https://www.vision.tuhh.de (funktioniert nur mit installiertem Flash)<br>4. Andreas Hirsch-Weber, Stefan Scherer: Wissenschaftliches Arbeiten und Abschlussarbeit in Natur- und Ingenieurwissenschaften : Grundlagen, Praxisbeispiele, Übungen. Stuttgart: Ulmer, 2016.<br>5. Werner Sesink: Einführung in das wissenschaftliche Arbeiten : inklusive E-Learning, Web-Recherche, digitale Präsentation u.a. 9., aktualisierte Aufl. München : Oldenbourg, 2012.<br>6. Judith Theuerkauf: Schreiben im Ingenieurstudium : effektiv und effizient zur Bachelor-, Master- und Doktorarbeit. Paderborn : Schöningh, 2012.<br>7. Wolfsberger, Judith: Frei geschrieben : Mut, Freiheit & Strategie für wissenschaftliche Abschlussarbeiten. Wien: Böhlau, 2010<br>8. Biedermann, Wieland u.a.: Forschungsmethodik in den Ingenieurwissenschaften : Skript vom Lehrstuhl für Produktentwicklung, Prof. Dr.-Ing. Udo Lindemann, Technische Universität München (TUM), 2012. https://www.mw.tum.de/fileadmin/w00btx/lpl/Documents/Forschungsmethodik_Skript.pdf<br>9. Wissenschaftliches Arbeiten - HOOU Angebot der HCU Hamburg: https://blogs.hoou.de/wissarbeiten/<br><br>1. Course Reserves Collection "Scholarly Research Methods" in the TUHH library: http://tinyurl.com/Semesterapparat-Wiss-Arbeiten<br>2. Scholarly research methods via TUHH library Website: https://www.tub.tuhh.de/en/scholarly-research-methods/<br>3. VISION - Online-Tutorial on research methods by the TUHH library: http://www.vision.tuhh.de (Flash has to be installed)<br>4. Scientific papers and presentations / Martha Davis. 3. ed. Amsterdam: Elsevier / Academic Press, 2013. http://www.sciencedirect.com/science/book/9780123847270<br>5. Writing for science and engineering : papers, presentations and reports / Heather Silyn-Roberts. 2nd ed. Amsterdam : Elsevier, 2013. http://www.sciencedirect.com/science/book/9780080982854<br>6. How to research / Loraine Blaxter, Christina Hughes and Malcolm Tight. Maidenhead : Open Univ. Press, 2010.<br>7. Managing information for research : practical help in researching, writing and designing dissertations / Elizabeth Orna and Graham Stevens. Maidenhead : Open University Press McGraw-Hill, 2009.<br>8. Writing scientific research articles : strategy and steps / Margaret Cargill and Patrick O'Connor. Chichester : Wiley-Blackwell, 2009. |

## Module M0610: Electrical Machines and Actuators

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Electrical Machines and Actuators (L0293) | Lecture | 3 | 4 |
| Electrical Machines and Actuators (L0294) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Thorsten Kern |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of mathematics, in particular complexe numbers, integrals, differentials<br><br>Basics of electrical engineering and mechanical engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can to draw and explain the basic principles of electric and magnetic fields.<br><br>They can describe the function of the standard types of electric machines and present the corresponding equations and characteristic curves. For typically used drives they can explain the major parameters of the energy efficiency of the whole system from the power grid to the driven engine. |
| *Skills* | Students are able to calculate two-dimensional electric and magnetic fields in particular ferromagnetic circuits with air gap. For this they apply the usual methods of the design auf electric machines.<br><br>They can calulate the operational performance of electric machines from their given characteristic data and selected quantities and characteristic curves. They apply the usual equivalent circuits and graphical methods. |
| **Personal Competence** | |
| *Social Competence* | none |
| *Autonomy* | Students are able independently to calculate electric and magnatic fields for applications. They are able to analyse independently the operational performance of electric machines from the charactersitic data and theycan calculate thereof selected quantities and characteristic curves. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Design of four machines and actuators, review of design files |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Engineering Science: Specialisation Electrical Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Elective Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory |

| Course L0293: Electrical Machines and Actuators | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Thorsten Kern, Dennis Kähler |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Electric field: Coulomb´s law, flux (field) line, work, potential, capacitor, energy, force, capacitive actuators<br><br>Magnetic field: force, flux line, Ampere´s law, field at bounderies, flux, magnetic circuit, hysteresis, induction, self-induction, mutual inductance, transformer, electromagnetic actuators<br><br>Synchronous machines, construction and layout, equivalent single line diagrams, no-load and short-cuircuit characteristics, vector diagrams, motor and generator operation, stepper motors<br><br>DC-Machines: Construction and layout, torque generation mechanismen, torque vs speed characteristics, commutation,<br><br>Asynchronous Machines. Magnetic field, construction and layout, equivalent single line diagram, complex stator current diagram (Heylands´diagram), torque vs. speed characteristics, rotor layout (squirrel-cage vs. sliprings),<br><br>Drives with variable speed, inverter fed operation, special drives |
| **Literature** | Hermann Linse, Roland Fischer: "Elektrotechnik für Maschinenbauer", Vieweg-Verlag; Signatur der Bibliothek der TUHH: ETB 313<br><br>Ralf Kories, Heinz Schmitt-Walter: "Taschenbuch der Elektrotechnik"; Verlag Harri Deutsch; Signatur der Bibliothek der TUHH: ETB 122<br><br>"Grundlagen der Elektrotechnik" - anderer Autoren<br><br>Fachbücher "Elektrische Maschinen" |

| Course L0294: Electrical Machines and Actuators | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Kern, Dennis Kähler |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0594: Fundamentals of Mechanical Engineering Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Mechanical Engineering Design (L0258) | Lecture | 2 | 3 |
| Fundamentals of Mechanical Engineering Design (L0259) | Recitation Section (large) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Basic knowledge about mechanics and production engineering<br>• Internship (Stage I Practical) |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After passing the module, students are able to:<br>• explain basic working principles and functions of machine elements,<br>• explain requirements, selection criteria, application scenarios and practical examples of basic machine elements, indicate the background of dimensioning calculations. |
| *Skills* | After passing the module, students are able to:<br>• accomplish dimensioning calculations of covered machine elements,<br>• transfer knowledge learned in the module to new requirements and tasks (problem solving skills),<br>• recognize the content of technical drawings and schematic sketches,<br>• technically evaluate basic designs. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to discuss technical information in the lecture supported by activating methods. |
| *Autonomy* | • Students are able to independently deepen their acquired knowledge in exercises.<br>• Students are able to acquire additional knowledge and to recapitulate poorly understood content e.g. by using the video recordings of the lectures. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory |

| Course L0258: Fundamentals of Mechanical Engineering Design | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Nikola Bursac, Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | **Lecture**<br>• Introduction to design<br>• Introduction to the following machine elements<br>  ◦ Screws<br>  ◦ Shaft-hub joints<br>  ◦ Rolling contact bearings<br>  ◦ Welding / adhesive / solder joints<br>  ◦ Springs<br>  ◦ Axes & shafts<br>• Presentation of technical objects (technical drawing)<br>**Exercise**<br>• Calculation methods for dimensioning the following machine elements:<br>  ◦ Screws<br>  ◦ Shaft-hub joints<br>  ◦ Rolling contact bearings<br>  ◦ Welding / adhesive / solder joints<br>  ◦ Springs<br>  ◦ Axis & shafts |
| **Literature** | • Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage.<br>• Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage.<br>• Einführung in die DIN-Normen; Klein, M., Teubner-Verlag.<br>• Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage.<br>• Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage.<br>• Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage.<br>• Sowie weitere Bücher zu speziellen Themen |

| Course L0259: Fundamentals of Mechanical Engineering Design | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Nikola Bursac, Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0829: Foundations of Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Management Tutorial (L0882) | Recitation Section (small) | 2 | 3 |
| Introduction to Management (L0880) | Lecture | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Christian Lüthje |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic Knowledge of Mathematics and Business |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After taking this module, students know the important basics of many different areas in Business and Management, from Planning and Organisation to Marketing and Innovation, and also to Investment and Controlling. In particular they are able to<br>• explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management<br>• explain the most important aspects of and goals in Management and name the most important aspects of entreprneurial projects<br>• describe and explain basic business functions as production, procurement and sourcing, supply chain management, organization and human ressource management, information management, innovation management and marketing<br>• explain the relevance of planning and decision making in Business, esp. in situations under multiple objectives and uncertainty, and explain some basic methods from mathematical Finance<br>• state basics from accounting and costing and selected controlling methods. |
| *Skills* | Students are able to analyse business units with respect to different criteria (organization, objectives, strategies etc.) and to carry out an Entrepreneurship project in a team. In particular, they are able to<br>• analyse Management goals and structure them appropriately<br>• analyse organisational and staff structures of companies<br>• apply methods for decision making under multiple objectives, under uncertainty and under risk<br>• analyse production and procurement systems and Business information systems<br>• analyse and apply basic methods of marketing<br>• select and apply basic methods from mathematical finance to predefined problems<br>• apply basic methods from accounting, costing and controlling to predefined problems |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• work successfully in a team of students<br>• to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project<br>• to communicate appropriately and<br>• to cooperate respectfully with their fellow students. |
| *Autonomy* | Students are able to<br>• work in a team and to organize the team themselves<br>• to write a report on their project. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | several written exams during the semester plus final test (90 minutes) |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Specialisation Biomechanics: Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Compulsory |

| | |
|---|---|
| | Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory<br>Mechanical Engineering: Specialisation Product Development and Production: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| **Course L0882: Management Tutorial** | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Lüthje, Katharina Roedelius |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | In the management tutorial, the contents of the lecture will be deepened by practical examples and the application of the discussed tools.<br><br>If there is adequate demand, a problem-oriented tutorial will be offered in parallel, which students can choose alternatively. Here, students work in groups on se selected projects that focus on the elaboration of an innovative business idea from the point of view of an established company or a startup. Again, the busin knowledge from the lecture should come to practical use. The group projects are guided by a mentor. |
| **Literature** | Relevante Literatur aus der korrespondierenden Vorlesung. |

| Course L0880: Introduction to Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Matthias Meyer, Prof. Christian Lüthje, Prof. Christian Ringle, Prof. Christian Thies, Prof. Christoph Ihl, Prof. Kathrin Fischer, Prof. Moritz Göldner, Prof. Thomas Wrona, Prof. Thorsten Blecker, Prof. Tim Schweisfurth, Prof. Wolfgang Kersten |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | • Introduction to Business and Management, Business versus Economics, relevant areas in Business and Management<br>• Important definitions from Management,<br>• Developing Objectives for Business, and their relation to important Business functions<br>• Business Functions: Functions of the Value Chain, e.g. Production and Procurement, Supply Chain Management, Innovation Management, Marketing and Sales<br>Cross-sectional Functions, e.g. Organisation, Human Ressource Management, Supply Chain Management, Information Management<br>• Definitions as information, information systems, aspects of data security and strategic information systems<br>• Definition and Relevance of innovations, e.g. innovation opporunities, risks etc.<br>• Relevance of marketing, B2B vs. B2C-Marketing<br>• different techniques from the field of marketing (e.g. scenario technique), pricing strategies<br>• important organizational structures<br>• basics of human ressource management<br>• Introduction to Business Planning and the steps of a planning process<br>• Decision Analysis: Elements of decision problems and methods for solving decision problems<br>• Selected Planning Tasks, e.g. Investment and Financial Decisions<br>• Introduction to Accounting: Accounting, Balance-Sheets, Costing<br>• Relevance of Controlling and selected Controlling methods<br>• Important aspects of Entrepreneurship projects |
| **Literature** | Bamberg, G., Coenenberg, A.: Betriebswirtschaftliche Entscheidungslehre, 14. Aufl., München 2008<br><br>Eisenführ, F., Weber, M.: Rationales Entscheiden, 4. Aufl., Berlin et al. 2003<br><br>Heinhold, M.: Buchführung in Fallbeispielen, 10. Aufl., Stuttgart 2006.<br><br>Kruschwitz, L.: Finanzmathematik. 3. Auflage, München 2001.<br><br>Pellens, B., Fülbier, R. U., Gassen, J., Sellhorn, T.: Internationale Rechnungslegung, 7. Aufl., Stuttgart 2008.<br><br>Schweitzer, M.: Planung und Steuerung, in: Bea/Friedl/Schweitzer: Allgemeine Betriebswirtschaftslehre, Bd. 2: Führung, 9. Aufl., Stuttgart 2005.<br><br>Weber, J., Schäffer, U. : Einführung in das Controlling, 12. Auflage, Stuttgart 2008.<br><br>Weber, J./Weißenberger, B.: Einführung in das Rechnungswesen, 7. Auflage, Stuttgart 2006. |

# Specialization Water Technologies

In the specialisation "Water", process engineering, construction and environmental science contents and competences are combined in a comprehensive water-specific subject area. Students gain a deeper understanding of the interactions and interfaces between urban water management and ecosystems as well as water and energy management.

## Module M1627: Water and Environment

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Project on Water, Environment, Traffic (L2462) | Project-/problem-based Learning | 2 | 3 |
| Water in the Environment (L2461) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Mathias Ernst |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of chemistry |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can define generic material interactions between the environmental media. The can demonstrate their knowledge about natural as well as anthropogenic materials. They are capable of explaining the natural condition of waters and other environmental media. |
| *Skills* | Students are able to research environment-specific aspects of civil engineering independent. They can present their findings using accredited academic media (e.g. posters) and can give a short summary including scientific references. |
| **Personal Competence** | |
| *Social Competence* | Students can fulfil a complex environment-related assignment in the field of civil engineering by working in a team. |
| *Autonomy* | Individual students prepare aspects of the given group work independently. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** None; **Form** Presentation; **Description** Team-Projektarbeit mit Präsentation |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory |

### Course L2462: Project on Water, Environment, Traffic

| | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des SD B |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Lecturers of Civicl Engineering provide duties on environmentally relevant fields of civil engineering for smal student groups (max. 4 students). |
| **Literature** | aufgabenspeziifisch / according to corresponding tasks |

### Course L2461: Water in the Environment

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Mathias Ernst, Dozenten des SD B |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Basics of global/regional Water Cycle<br>• quality of water<br>• natural/anthropogenic water ingredients<br>• Basics water science<br>• water legislation (EU/D) |
| **Literature** | Schwoerbel, J. 2005: Einführung in die Limnologie. Heidelberg: Elsevier<br><br>Grohmann, A. u. a. 2011: Wasser. Berlin: de Gruyter<br><br>Kluth, W. & Schmeddinck, U. 2013: Umweltrecht: Ein Lehrbuch. Wiesbaden: Springer |

## Module M1727: Hydrology and Geoinformation Systems

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Geoinformation Science (L2465) | Project-/problem-based Learning | 3 | 3 |
| Hydrology (L0909) | Lecture | 1 | 1 |
| Hydrology (L0956) | Project-/problem-based Learning | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I, II and III<br><br>Mechanics I and II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to define the basic terms of hydrology, groundwater hydrology and water management. They are able to describe and quantify the basic equations and the relevant processes of the water cycle. In addition, they can describe the essential aspects of precipitation-runoff modeling and can explain, for example, the derivation of common storage models or a unit hydrograph by theoretical means.<br><br>Students will be able to define the tasks and terms from the application area of geo-information systems. They can describe the fundamentals, basic approaches and methods of geo-information systems and are able to transfer these to practical issues. |
| *Skills* | Students are able to apply the approaches and methods commonly used in hydrology. They can theoretically derive and apply common storage models or a unit hydrograph as basis for precipitation-runoff modelling. In addition, students are able to explain basic concepts of measurements of hydrological and hydrodynamic variables in nature and are able to carry out, statistically evaluate and assess corresponding measurements.<br><br>Students are able to recognize and process fundamental questions that fall within the scope of geo-information systems. They can use geo-information systems for simple applications and transfer the methods to other issues. |
| **Personal Competence** | |
| *Social Competence* | Students are able to work together in groups in a planned and goal-oriented manner and to communicate the results obtained in the team to other participants of the course using peer learning methods. In addition, students are able to prepare short technical presentations on given topics and present them in an appropriate manner. |
| *Autonomy* | Students can organize individual work processes in the context of experiments and for the presentation of subject specific content. They can give each other feedback on individual and group performance. Students are able to reflect independently on their learning and their learning strategy. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | ? |
| **Assignment for the Following Curricula** | Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory |

### Course L2465: Introduction to Geoinformation Science

| | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Yohannis Tadesse |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Theoretical basics of Geo-Information-Systems<br>• Data models, geographical coordinates, geo-referencing, map-views<br>• Data mining and -analyses of geo-data<br>• Analysis techniques |
| **Literature** | |

| Course L0909: Hydrology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Introduction to basics of hydrology and groundwater hydrology:<br>• Hydrological cycle<br>• Data acquisition in hydrology<br>• Data analyses and statistical assessment<br>• Statistics of extremes<br>• Regionalization methods for hydrological values<br>• rainfall-run-off modelling on the basis of a unit hydrograph concept |
| **Literature** | Maniak, U. (2017). Hydrologie und Wasserwirtschaft: Eine Einführung für Ingenieure. Springer Vieweg.<br>Skript "Hydrologie und Gewässerkunde" |

| Course L0956: Hydrology | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Introduction to basics of Hydrology:<br>• Hydrological cycle<br>• Data acquisition<br>• Data analyses and statistical assessment<br>• Statistics of extremes<br>• Regionalization methods for hydrological values<br>Rainfall-run-off modelling on the basis of a unit hydrograph conceps |
| **Literature** | Maniak, Hydrologie und Wasserwirtschaft, Eine Einführung für Ingenieure, Springer<br>Skript Hydrologie und Gewässerkunde |

## Module M1722: New Trends in Water and Environmental Research

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Microplastics in Environment (L2755) | Integrated Lecture | 2 | 2 |
| Research Methods (L2756) | Lecture | 1 | 2 |
| Research Trends (L2757) | Seminar | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Nima Shokri |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in water and environmental-related research |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students will be introduced to current research topics relevant to water and environment with a particular focus on the effects of microplastics in environment (introductory level). Data analysis, curation and presentation will be other skills discussed in this module. |
| *Skills* | Students' research and academics skills will be improved in this module. How to prepare and deliver an effective research presentation, how to write an abstract, research paper and proposal will be explained in this module. |
| **Personal Competence** | |
| *Social Competence* | Developing teamwork and problem solving skills through Research-Based Teaching approaches will be at the core of this module. |
| *Autonomy* | The students will be involved in writing individual project reports and giving research presentation. This will contribute to the students' ability and willingness to work independently and responsibly. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Report and Presentation |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory |

### Course L2755: Introduction to Microplastics in Environment

| | |
|---|---|
| **Typ** | Integrated Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Nima Shokri |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Introduction - course objectives, expectations and format;<br>Source of microplastics in environment;<br>Microplastics sampling; Characterization of microplastics;<br>Fate and distribution of microplastics in terrestrial environments;<br>Effects of microplastics on terrestrial environments;<br>Health risks of microplastics in environments |
| **Literature** | 1- Characterization and Analysis of Microplastics, Volume 75 1st Edition<br>Series Volume Editors: Teresa Rocha-Santos Armando Duarte<br>Elsevier, published in 2017<br>2- Microplastic Pollutants 1st Edition<br>Authors: Christopher Blair Crawford, Brian Quinn<br>Elsevier Science, published in 2016<br>3- Microplastics in Terrestrial Environments<br>Authors: Defu He and Yongming Luo<br>Springer, published in 2020, DOI https://doi.org/10.1007/978-3-030-56271-7 |

| Course L2756: Research Methods | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Nima Shokri |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Introduction - course objectives, expectations and format<br>Analyzing the Audience, purpose and occasion<br>Constructing and delivering effective technical presentations<br>How to write an abstract<br>How to create a scientific poster<br>How to write a scientific paper<br>Individual project on water and environmental research<br>Presentation on water and environmental research |
| **Literature** | • The Craft of Scientific Writing Fourth edition<br>Author: Michael Alley<br>Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9<br>• Supplemental materials and web links which will be available to registered students. |

| Course L2757: Research Trends | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Salome Shokri-Kuehni |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Introduction - course objectives, expectations and format<br>Analyzing the Audience, purpose and occasion<br>Constructing and delivering effective technical presentations<br>How to write an abstract<br>How to write a scientific paper<br>Developing competitive and persuasive research proposals<br>Databases and resources available for water and environmental research<br>Individual proposal on water and environmental research<br>Individual project on water and environmental research<br>Group projects and presentation on water and environmental research |
| **Literature** | • The Craft of Scientific Writing Fourth edition<br>Author: Michael Alley<br>Springer-Verlag New York, Copyright 2018, DOI 10.1007/978-1-4419-8288-9<br>• Supplemental materials and web links which will be available to registered students. |

## Module M0869: Hydraulic Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Hydraulics (L0957) | Lecture | 1 | 1 |
| Hydraulics (L0958) | Project-/problem-based Learning | 1 | 1 |
| Hydraulic Engineering (L0959) | Lecture | 2 | 2 |
| Hydraulic Engineering (L0960) | Project-/problem-based Learning | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Hydraulic Mechanics and Hydrology |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to define the basic terms of hydraulic engineering and hydraulics. They are able to explain the application of basic hydrodynamic formulations (conservation laws) to practical hydraulic engineering problems. Besides this, the students can illustrate important tasks of hydraulic engineering and give an overview over river engineering, flood protection, hydraulic power engineering and waterways engineering. |
| *Skills* | The students are able to apply hydraulic engineering methods and approaches to basic practical problems and design respective hydraulic engineering systems. Besides this, they are able to use and apply established approaches of hydraulics and determine water surfaces of channel flows, influences of constructions (weirs, etc.) on channel flows as well as flow conditions of pipe system. Furthermore, they are able to run, explain and document basic hydraulic experiments. |
| **Personal Competence** | |
| *Social Competence* | The students are able to deploy their gained knowledge in applied problems. Additionaly, they will be able to work in team with engineers of other disciplines in a goal-orientated, structured manner. They can explain their results by use of peer learning approaches. |
| *Autonomy* | The students will be able to independently extend their knowledge and apply it to new problems. Furthermore, they are capable of organising their individual work flow to contribute to the conduct of experiments and to present discipline-specific knowledge. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**: Yes / None / Subject theoretical and practical work / Durchführung, Dokumentation und Präsentation zu einem Versuchs Hydromechanik oder Hydraulik |
| **Examination** | Written exam |
| **Examination duration and scale** | The duration of the examination is 2.5 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks. |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory |

### Course L0957: Hydraulics

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Flow of incompressible fluids in pipes and open channels<br>• Pumps in hydraulic systems<br>• Open channel flow<br>• Regulative construction in open channel flow<br>  ◦ Weirs<br>  ◦ Sliding panels<br>  ◦ Cross-section reduction by constructions |
| **Literature** | Zanke, Ulrich C. , Hydraulik für den WasserbauUrsprünglich erschienen unter: Schröder/Zanke "Technische Hydraulik", Springer-Verlag, 2003<br><br>Naudascher, E.: Hydraulik der Gerinne und Gerinnebauwerke, Springer, 1992 |

| Course L0958: Hydraulics | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0959: Hydraulic Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Fundamentals of hydraulic engineering<br>• Introduction and hydrological cycle<br>• River engineering<br>  ◦ Regime theory of natural rivers<br>  ◦ Sediment transport<br>  ◦ Regulation of rivers<br>  ◦ Bank protection / protection of river bed<br>  ◦ Tidal rivers<br>• Flood protection<br>  ◦ Dikes<br>  ◦ Flood contraol basins<br>• Hydraulic power<br>• Inland waterways engineering<br>  ◦ waterways<br>  ◦ Locks and ship lifts<br>  ◦ Fish passages<br>• Nature-oriented hydraulic engineering |
| **Literature** | Strobl, T. & Zunic, F: Wasserbau, Springer 2006<br><br>Patt, H. & Gonsowski, P: Wasserbau, Springer 2011 |

| Course L0960: Hydraulic Engineering | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1713: Green Technologies III

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Study Work Green Technologies (L2766) | Project Seminar | 2 | 4 |
| Scientific Work and Writing (L2765) | Seminar | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Dozenten des Studiengangs |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | keine |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students, based on a literature survey, learn to study in detail a subject theme from the disciplines of green technologies and deliver afterwards a summary presentation to a specialised audience. Environmental issues and their multidisciplinary linkages are preferred, when selecting the thematic area of these studies. Through their own written contribution the students communicate an overview over the subject and practice technical writing. With the discussion the students practice scientific debating on a specialised subject matter. |
| *Skills* | The students can, when working on a technical topic not familiar to them:<br>• conduct a literature survey<br>• choose the relevant information for their presentation<br>• prepare a written summary<br>• present results in front of peers and staff<br>• correctly cite and reference sources. |
| **Personal Competence** | |
| *Social Competence* | The students practice a critical assessment of the literature in a predefined specialised theme and learn to give presentations on their own technical sub-topic tailored to their public and discuss with the audience. When attending technical presentations, the students can formulate questions to other speakers and participate in the ensuing discussion.<br>The fulfilment of the tasks combines independent work with group and teamwork. |
| *Autonomy* | The students can, guided by instructors, critically reflect on their learning and work status, and write a scientific report. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Study work |
| **Examination duration and scale** | - |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory |

### Course L2766: Study Work Green Technologies

| | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Studiengangs |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Students carry out a research project in a scientific field under the guidance of an academic staff member. For this purpose, the student can approach the staff of the respective institute and discuss a topic. The topic is then worked on within 4 weeks and regular consultations are held with the supervisor. The student research project should be the size of a scientific article and must be presented to the lecturer after completion as part of a presentation (approx. 15 minutes). |
| **Literature** | |

| Course L2765: Scientific Work and Writing | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Studiengangs, Dr. Detlev Bieler, Florian Hagen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The seminar offers an introduction into the diverse aspects of academic research and writing: Finding the topic, finding specialized information, knowledge organisation, writing, presenting and publishing. Suggestions for reflecting own processes of learning, informing and writing - in addition to practical recommendations and tips - facilitate the start and the creation of bachelor and master theses, works, which bring thoroughly self-fulfillment and make fun.<br><br>Topics of the seminar will be in particular<br><br>• Scientific scholarship and academic research methods:<br>• Introduction, organization, attributes of science:<br>How is scientific knowledge created?<br>Work scheduling, finding topics, time management, specialities of academic research in engineering<br>• Finding specialized information: Full texts and library resources, databases http://www.tub.tuhh.de/en/subject-information/informing-points-to-survive/<br>• Reference management: http://www.tub.tuhh.de/en/publishing/reference-management/<br>Knowledge organisation and creating publications with Citavi<br>• Citing correctly and avoiding plagiarism<br>• Preparing and doing presentations |
| **Literature** | 1. Semesterapparat "Wissenschaftliches Arbeiten" in der TU-Bibliothek: http://tinyurl.com/Semesterapparat-Wiss-Arbeiten<br>2. Weblog Wissenschaftliches Arbeiten der TU-Bibliothek: https://www.tub.tuhh.de/wissenschaftliches-arbeiten/<br>3. Online-Tutorial VISION der TU-Bibliothek zum wissenschaftlichen Arbeiten: https://www.vision.tuhh.de (funktioniert nur mit installiertem Flash)<br>4. Andreas Hirsch-Weber, Stefan Scherer: Wissenschaftliches Arbeiten und Abschlussarbeit in Natur- und Ingenieurwissenschaften : Grundlagen, Praxisbeispiele, Übungen. Stuttgart: Ulmer, 2016.<br>5. Werner Sesink: Einführung in das wissenschaftliche Arbeiten : inklusive E-Learning, Web-Recherche, digitale Präsentation u.a. 9., aktualisierte Aufl. München : Oldenbourg, 2012.<br>6. Judith Theuerkauf: Schreiben im Ingenieurstudium : effektiv und effizient zur Bachelor-, Master- und Doktorarbeit. Paderborn : Schöningh, 2012.<br>7. Wolfsberger, Judith: Frei geschrieben : Mut, Freiheit & Strategie für wissenschaftliche Abschlussarbeiten. Wien: Böhlau, 2010<br>8. Biedermann, Wieland u.a.: Forschungsmethodik in den Ingenieurwissenschaften : Skript vom Lehrstuhl für Produktentwicklung, Prof. Dr.-Ing. Udo Lindemann, Technische Universität München (TUM), 2012. https://www.mw.tum.de/fileadmin/w00btx/lpl/Documents/Forschungsmethodik_Skript.pdf<br>9. Wissenschaftliches Arbeiten - HOOU Angebot der HCU Hamburg: https://blogs.hoou.de/wissarbeiten/<br><br>1. Course Reserves Collection "Scholarly Research Methods" in the TUHH library: http://tinyurl.com/Semesterapparat-Wiss-Arbeiten<br>2. Scholarly research methods via TUHH library Website: https://www.tub.tuhh.de/en/scholarly-research-methods/<br>3. VISION - Online-Tutorial on research methods by the TUHH library: http://www.vision.tuhh.de (Flash has to be installed)<br>4. Scientific papers and presentations / Martha Davis. 3. ed. Amsterdam: Elsevier / Academic Press, 2013. http://www.sciencedirect.com/science/book/9780123847270<br>5. Writing for science and engineering : papers, presentations and reports / Heather Silyn-Roberts. 2nd ed. Amsterdam : Elsevier, 2013. http://www.sciencedirect.com/science/book/9780080982854<br>6. How to research / Loraine Blaxter, Christina Hughes and Malcolm Tight. Maidenhead : Open Univ. Press, 2010.<br>7. Managing information for research : practical help in researching, writing and designing dissertations / Elizabeth Orna and Graham Stevens. Maidenhead : Open University Press McGraw-Hill, 2009.<br>8. Writing scientific research articles : strategy and steps / Margaret Cargill and Patrick O'Connor. Chichester : Wiley-Blackwell, 2009. |

## Module M0670: Particle Technology and Solids Process Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Particle Technology I (L0434) | Lecture | 2 | 3 |
| Particle Technology I (L0435) | Recitation Section (small) | 1 | 1 |
| Particle Technology I (L0440) | Practical Course | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Stefan Heinrich |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | keine |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After successful completion of the module students are able to<br>• name and explain processes and unit-operations of solids process engineering,<br>• characterize particles, particle distributions and to discuss their bulk properties |
| *Skills* | Students are able to<br>• choose and design apparatuses and processes for solids processing according to the desired solids properties of the product<br>• asses solids with respect to their behavior in solids processing steps<br>• document their work scientifically. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss scientific topics orally with other students or scientific personal and to develop solutions for technical-scientific issues in a group. |
| *Autonomy* | Students are able to analyze and solve questions regarding solid particles independently. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: Yes; Bonus: None; Form: Written elaboration; Description: sechs Berichte (pro Versuch ein Bericht) à 5-10 Seiten |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

### Course L0434: Particle Technology I

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Stefan Heinrich |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Description of particles and particle distributions<br>• Description of a separation process<br>• Description of a particle mixture<br>• Particle size reduction<br>• Agglomeration, particle size enlargement<br>• Storage and flow of bulk solids<br>• Basics of fluid/particle flows<br>• classifying processes<br>• Separation of particles from fluids<br>• Basic fluid mechanics of fluidized beds<br>• Pneumatic and hydraulic transport |
| **Literature** | Schubert, H.; Heidenreich, E.; Liepe, F.; Neeße, T.: Mechanische Verfahrenstechnik. Deutscher Verlag für die Grundstoffindustrie, Leipzig, 1990.<br><br>Stieß, M.: Mechanische Verfahrenstechnik I und II. Springer Verlag, Berlin, 1992. |

| Course L0435: Particle Technology I | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Stefan Heinrich |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0440: Particle Technology I | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Stefan Heinrich |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | • Sieving<br>• Bulk properties<br>• Size reduction<br>• Mixing<br>• Gas cyclone<br>• Blaine-test, filtration<br>• Sedimentation |
| **Literature** | Schubert, H.; Heidenreich, E.; Liepe, F.; Neeße, T.: Mechanische Verfahrenstechnik. Deutscher Verlag für die Grundstoffindustrie, Leipzig, 1990.<br><br>Stieß, M.: Mechanische Verfahrenstechnik I und II. Springer Verlag, Berlin, 1992. |

## Module M1632: Applied Water Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Modelling of soil water dynamics (L2471) | Project-/problem-based Learning | 2 | 2 |
| Modelling of soil water dynamics (L2470) | Lecture | 2 | 2 |
| Nature-oriented Hydraulic Engineering (L2472) | Project-/problem-based Learning | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Basic knowledge of analysis and differential equations<br>• hydromechanical and hydraulic engineering principles |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to define the basic tasks and terms of nature-oriented hydraulic engineering und groundwater hydrology. They cam describe the basics concepts, the basic approaches and methods of nature-oriented hydraulic engineering, groundwater hydrology and groundwater modelling and are able to apply these to practical problems. |
| *Skills* | The students are able to apply the methods and approaches of nature-oriented hydraulic engineering and of groundwater hydrology to practical problems. They can demonstrate to transfer and apply these to simple hydraulic engineering systems. In addition, they are able to apply the approaches commonly used in groundwater hydrology. They can exemplarily explain and reason how to apply them as a basis for geo-hydrological questions. In addition, students can apply basic groundwater modelling methods to simple problems of groundwater movement and groundwater recharge. |
| **Personal Competence** | |
| *Social Competence* | Students are able to help each other solving case studies. The students are able to deploy their gained knowledge in applied problems of the practical nature-based hydraulic engineering. Additionaly, they will be able to demonstrate to work cooperatively in teams consisting of engineers from different subject areas. |
| *Autonomy* | The students will be able to independently extend their knowledge and apply it to new problems. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Written-theoretical part and modeling |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory |

### Course L2471: Modelling of soil water dynamics

| | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Hannes Nevermann |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

### Course L2470: Modelling of soil water dynamics

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Mohammad Aziz Zarif |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Students will learn about soil physical characteristics, soil water potential, saturated and unsaturated flows in soil, basics of solute transport in soil, and numerical methods/tools to simulate water flow and solute transport in soil. |
| **Literature** | |

| Course L2472: Nature-oriented Hydraulic Engineering | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Nature oriented hydraulic engineering<br>• Regime-theory and application for the development of environmental guiding priciples of rivers<br>• Engineering-biological measures for the stabilization of rivers<br>• design techniques for water engineering<br>• hydraulic dimensioning of river bed and bank protection<br>• design principles and design techniques for fish passages (fish ladder, ramps etc.) |
| **Literature** | Patt, Heinz (2018): Naturnaher Wasserbau. Entwicklung und Gestaltung von Fließgewässern. With assistance of Peter Jürging, Werner Kraus. 5. Auflage. Wiesbaden: Springer Vieweg. |

## Module M1630: Sanitary Engineering II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Management of Wastewater Infrastructure (L2467) | Seminar | 2 | 3 |
| Drinking Water Treatment (L2466) | Seminar | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Mathias Ernst |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in the field of drinking water supply and waste water disposal. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can examplify their expert knowledge on drinking water, waste water treatment and the associated infrastructure systems. They are capable of reproducing the relevant empiricals assumptions and scientific simplifcations in detail. The students can model some processes mathematically. They can also assess existing problems in the field of sanitary engineering, such as removal of nitrate, and place them in a socio-political context. Furthermore, they know how to draft the features and effectiveness of important technologies of the future such as high- and low-pressure membrane filtration systems and techniques. |
| *Skills* | The students are able to apply the relevant standards and guidelines for the design and operation of urban water infrastructures independently. Their expertise comprises expert skills to design drinking water supply and urban drainage systems as well as the associated treatment facilities. Besides the acquirement of technical skills the students are able to address and solve biochemical problems in the filed of drinking water and wastewater treatment. The students are also able to develop ideas of their own to improve the existing water related infrastructures, systems and concepts. |
| **Personal Competence** | |
| *Social Competence* | The students are able to develop a specific topic in a team and to work out milestones according to a given plan. |
| *Autonomy* | Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Written-theoretical part and modelling |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Water and Environment: Compulsory<br>Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory |

### Course L2467: Management of Wastewater Infrastructure

| | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The seminar ""Infrastructure Management Wastewater"" develops the understanding of infrastructure systems in relation to wastewater systems, but also addresses other infrastructure systems.<br><br>Initially, an overview of the entire system is given, including water catchment areas, water distribution, the origin of wastewater in households and industry, stormwater runoff management, and the treatment and reuse of water (constituents ). Thereby the design tools especially of digital modelling are understood by practical application. Energetic considerations as well as planning and restoration of pipeline systems are covered.<br><br>For wastewater treatment, the basis developed in Sanitary Engineering I will be deepened and significantly expanded, especially the resource recovery of nutrients and water. Sanitary solutions for different socio-economic and climatic conditions are understood and calculated. |
| **Literature** | Gujer, W. (2007): Siedlungswasserwirtschaft, Springer, Berlin Heidelberg<br><br>Metcalf and Eddy (2003): Wastewater Engineering : Treatment and Reuse, Boston, McGraw-Hill<br><br>Henze, M. (1997): Wastewater Treatment : Biological and Chemical Processes, Berlin, Springer<br><br>Stein D., Stein R. (2014): Instandhaltung von Kanalisationen, Verlag Prof. Dr.-Ing. Stein & Partner GmbH<br><br>Wossog, G. (2016): Handbuch für den Rohrleitungsbau Band 1 und 2<br><br>Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (2009): Abwasserableitung : Bemessungsgrundlagen, Regenwasserbewirtschaftung, Fremdwasser, Netzsanierung, Grundstücksentwässerung, Weimar, Univ.-Verl.<br><br>DWA Arbeitsblätter |

| Course L2466: Drinking Water Treatment | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Mathias Ernst, Dr. Klaus Johannsen |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The seminar deepens and expands the knowledge of the processes of drinking water treatment. The seminar deals with ion exchange, oxidation, disinfection, gas exchange and hybrid treatment processes. Further topics include pH adjustment and energy efficiency in water supply. Within the scope of the course, the students work out a seminar performance (presentation, design, modelling) on the basis of a task. |
| **Literature** | Worch, E. (2019): Drinking Water Treatment, De Gruyter-Verlag<br><br>Worch, E. (2015): Hydrochemistry, De Gruyter-Verlag<br><br>Jekel, M., Czekalla, C. (2016): Wasseraufbereitung - Grundlagen und Verfahren (DVGW Lehr- und Handbuch Wasserversorgung, Band 6), DIV Deutscher Industrieverlag |

## Module M0829: Foundations of Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Management Tutorial (L0882) | Recitation Section (small) | 2 | 3 |
| Introduction to Management (L0880) | Lecture | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Christian Lüthje |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic Knowledge of Mathematics and Business |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After taking this module, students know the important basics of many different areas in Business and Management, from Planning and Organisation to Marketing and Innovation, and also to Investment and Controlling. In particular they are able to<br>• explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management<br>• explain the most important aspects of and goals in Management and name the most important aspects of entreprneurial projects<br>• describe and explain basic business functions as production, procurement and sourcing, supply chain management, organization and human ressource management, information management, innovation management and marketing<br>• explain the relevance of planning and decision making in Business, esp. in situations under multiple objectives and uncertainty, and explain some basic methods from mathematical Finance<br>• state basics from accounting and costing and selected controlling methods. |
| *Skills* | Students are able to analyse business units with respect to different criteria (organization, objectives, strategies etc.) and to carry out an Entrepreneurship project in a team. In particular, they are able to<br>• analyse Management goals and structure them appropriately<br>• analyse organisational and staff structures of companies<br>• apply methods for decision making under multiple objectives, under uncertainty and under risk<br>• analyse production and procurement systems and Business information systems<br>• analyse and apply basic methods of marketing<br>• select and apply basic methods from mathematical finance to predefined problems<br>• apply basic methods from accounting, costing and controlling to predefined problems |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• work successfully in a team of students<br>• to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project<br>• to communicate appropriately and<br>• to cooperate respectfully with their fellow students. |
| *Autonomy* | Students are able to<br>• work in a team and to organize the team themselves<br>• to write a report on their project. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | several written exams during the semester plus final test (90 minutes) |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Specialisation Biomechanics: Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Compulsory |

| | |
|---|---|
| | Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory<br>Mechanical Engineering: Specialisation Product Development and Production: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| **Course L0882: Management Tutorial** | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Lüthje, Katharina Roedelius |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | In the management tutorial, the contents of the lecture will be deepened by practical examples and the application of the discussed tools.<br><br>If there is adequate demand, a problem-oriented tutorial will be offered in parallel, which students can choose alternatively. Here, students work in groups on se selected projects that focus on the elaboration of an innovative business idea from the point of view of an established company or a startup. Again, the busin knowledge from the lecture should come to practical use. The group projects are guided by a mentor. |
| **Literature** | Relevante Literatur aus der korrespondierenden Vorlesung. |

| Course L0880: Introduction to Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Matthias Meyer, Prof. Christian Lüthje, Prof. Christian Ringle, Prof. Christian Thies, Prof. Christoph Ihl, Prof. Kathrin Fischer, Prof. Moritz Göldner, Prof. Thomas Wrona, Prof. Thorsten Blecker, Prof. Tim Schweisfurth, Prof. Wolfgang Kersten |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | • Introduction to Business and Management, Business versus Economics, relevant areas in Business and Management<br>• Important definitions from Management,<br>• Developing Objectives for Business, and their relation to important Business functions<br>• Business Functions: Functions of the Value Chain, e.g. Production and Procurement, Supply Chain Management, Innovation Management, Marketing and Sales<br>Cross-sectional Functions, e.g. Organisation, Human Ressource Management, Supply Chain Management, Information Management<br>• Definitions as information, information systems, aspects of data security and strategic information systems<br>• Definition and Relevance of innovations, e.g. innovation opporunities, risks etc.<br>• Relevance of marketing, B2B vs. B2C-Marketing<br>• different techniques from the field of marketing (e.g. scenario technique), pricing strategies<br>• important organizational structures<br>• basics of human ressource management<br>• Introduction to Business Planning and the steps of a planning process<br>• Decision Analysis: Elements of decision problems and methods for solving decision problems<br>• Selected Planning Tasks, e.g. Investment and Financial Decisions<br>• Introduction to Accounting: Accounting, Balance-Sheets, Costing<br>• Relevance of Controlling and selected Controlling methods<br>• Important aspects of Entrepreneurship projects |
| **Literature** | Bamberg, G., Coenenberg, A.: Betriebswirtschaftliche Entscheidungslehre, 14. Aufl., München 2008<br><br>Eisenführ, F., Weber, M.: Rationales Entscheiden, 4. Aufl., Berlin et al. 2003<br><br>Heinhold, M.: Buchführung in Fallbeispielen, 10. Aufl., Stuttgart 2006.<br><br>Kruschwitz, L.: Finanzmathematik. 3. Auflage, München 2001.<br><br>Pellens, B., Fülbier, R. U., Gassen, J., Sellhorn, T.: Internationale Rechnungslegung, 7. Aufl., Stuttgart 2008.<br><br>Schweitzer, M.: Planung und Steuerung, in: Bea/Friedl/Schweitzer: Allgemeine Betriebswirtschaftslehre, Bd. 2: Führung, 9. Aufl., Stuttgart 2005.<br><br>Weber, J., Schäffer, U. : Einführung in das Controlling, 12. Auflage, Stuttgart 2008.<br><br>Weber, J./Weißenberger, B.: Einführung in das Rechnungswesen, 7. Auflage, Stuttgart 2006. |

# Thesis

## Module M1800: Bachelor thesis (dual study program)

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Professoren der TUHH |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Dual students...<br>• ... choose central theoretical principles from their field of study (facts, theories, methods) in relation to problems and applications, present them and discuss them critically.<br>• ... further develop their subject-related and practical knowledge as appropriate and link both areas of knowledge together.<br>• ... present the current research available on a chosen topic or on a chosen operational issue linked to their subject. |
| *Skills* | Dual students...<br>• ... evaluate both the basic knowledge linked to their field of study acquired at the university and professional knowledge gained through the company, then purposefully use it to solve technical and application-related problems.<br>• ... analyse questions and problems using the methods learned throughout their studies (including practical phases), reach factually justifiable decisions and develop application-specific solutions.<br>• ... critically analyse the results of their own research work from a subject-specific and professional perspective. |
| **Personal Competence** | |
| *Social Competence* | Dual students...<br>• ... present a professional problem in the form of an academic question for a specialist audience in a structured, comprehensible and factually correct manner, both orally and in writing.<br>• ... respond to questions as part of a specialist discussion and answer them appropriately. In doing so, they argue their own evaluations and points of view convincingly. |
| *Autonomy* | Dual students...<br>• ... structure a comprehensive, chronological workflow and work independently on a question to a high academic level within a given period of time.<br>• ... identify, develop and link necessary knowledge and material to handle an academic and application-related problem.<br>• ... apply the essential techniques of academic work when conducting their own research on an operational issue. |
| **Workload in Hours** | Independent Study Time 360, Study Time in Lecture 0 |
| **Credit points** | 12 |
| **Course achievement** | None |
| **Examination** | Thesis |
| **Examination duration and scale** | According to General Regulations |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Thesis: Compulsory<br>Civil- and Environmental Engineering: Thesis: Compulsory<br>Chemical and Bioprocess Engineering: Thesis: Compulsory<br>Computer Science: Thesis: Compulsory<br>Data Science: Thesis: Compulsory<br>Electrical Engineering: Thesis: Compulsory<br>Engineering Science: Thesis: Compulsory<br>Green Technologies: Energy, Water, Climate: Thesis: Compulsory<br>Computer Science in Engineering: Thesis: Compulsory<br>Mechanical Engineering: Thesis: Compulsory<br>Mechatronics: Thesis: Compulsory<br>Naval Architecture: Thesis: Compulsory<br>Technomathematics: Thesis: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Thesis: Compulsory |