TUHH
Hamburg
University of
Technology

# Module Manual

Bachelor of Science (B.Sc.)

# Green Technologies: Energy, Water, Climate

Cohort: Winter Term 2021

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# Table of Contents


Table of Contents 2
Program description 4
Core Qualification 6
Module M0850: Mathematics I 6
Module M0889: Mechanics I (Statics) 9
Module M0577: Non-technical Courses for Bachelors 11
Module M0883: General and Inorganic Chemistry 13
Module M1692: Computer Science for Engineers - Introduction and Overview 15
Module M1711: Green Technologies I 16
Module M0851: Mathematics II 19
Module M0696: Mechanics II: Mechanics of Materials 22
Module M0888: Organic Chemistry 24
Module M0671: Technical Thermodynamics I 26
Module M0608: Basics of Electrical Engineering 28
Module M0853: Mathematics III 30
Module M0688: Technical Thermodynamics II 33
Module M1497: Measurement Technology for Chemical and Bioprocess Engineering 35
Module M1712: Green Technologies II 37
Module M0536: Fundamentals of Fluid Mechanics 39
Module M0686: Sanitary Engineering I 42
Module M1714: Conventional Energy Systems and Energy Industry 45
Module M1715: Renewable Energies 47
Module M0538: Heat and Mass Transfer 49
Module M0833: Introduction to Control Systems 51
Module M1775: Economic and environmental project assessment 53
Specialization Biotechnologies 55
Module M0757: Biochemistry and Microbiology 55
Module M0892: Chemical Reaction Engineering 59
Module M0546: Thermal Separation Processes 63
Module M1713: Green Technologies III 68
Module M0945: Bioprocess Engineering - Advanced 70
Module M0539: Process and Plant Engineering I 72
Module M0544: Phase Equilibria Thermodynamics 75
Module M0938: Bioprocess Engineering - Fundamentals 78
Module M0829: Foundations of Management 81
Specialization Energy Systems / Renewable Energies 84
Module M1693: Computer Science for Engineers - Programming Concepts, Data Handling & Communication 84
Module M0546: Thermal Separation Processes 86
Module M1235: Electrical Power Systems I: Introduction to Electrical Power Systems 91
Module M1713: Green Technologies III 94
Module M1726: System Integration Renewable Energies 96
Module M1745: Climate physics 100
Module M1719: Climate change impact & mitigation 102
Module M0544: Phase Equilibria Thermodynamics 106
Module M0829: Foundations of Management 109
Specialization Energy Technology 112
Module M0594: Fundamentals of Mechanical Engineering Design 112
Module M0933: Fundamentals of Materials Science 114
Module M1713: Green Technologies III 116
Module M1022: Reciprocating Machinery 118
Module M0598: Mechanical Engineering: Design 121
Module M0662: Numerical Mathematics I 124
Module M0655: Computational Fluid Dynamics I 126
Module M0610: Electrical Machines and Actuators 128
Module M0725: Production Engineering 130
Module M0829: Foundations of Management 133
Specialization Maritime Technologies 136
Module M0659: Fundamentals of Ship Structural Design and Analysis 136
Module M1914: Fundamentals of renewable ocean utilization 139
Module M0933: Fundamentals of Materials Science 140
Module M1912: Green maritime energy conversion 142
Module M1913: Green maritime resources 143
Module M1118: Hydrostatics and Body Plan 144
Module M1804: Engineering Mechanics III (Dynamics) 147
Module M0655: Computational Fluid Dynamics I 149
Module M0610: Electrical Machines and Actuators 151
Module M0594: Fundamentals of Mechanical Engineering Design 153
Module M0829: Foundations of Management 155
Specialization Water Technologies 158
Module M1727: Hydrology and Geoinformation Systems 158

Module M1627: Water and Environment 160
Module M1722: New Trends in Water and Environmental Research 161
Module M0869: Hydraulic Engineering 163
Module M1713: Green Technologies III 165
Module M0670: Particle Technology and Solids Process Engineering 167
Module M1632: Applied Water Management 169
Module M1630: Sanitary Engineering II 171
Module M0829: Foundations of Management 173
Thesis 176
Module M-001: Bachelor Thesis 176

# 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.

## 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.

## 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.

## 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.

## 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 |
|---|---|---|---|
| Analysis I (L1010) | Lecture | 2 | 2 |
| Analysis I (L1012) | Recitation Section (small) | 1 | 1 |
| Analysis I (L1013) | Recitation Section (large) | 1 | 1 |
| Linear Algebra I (L0912) | Lecture | 2 | 2 |
| Linear Algebra I (L0913) | Recitation Section (small) | 1 | 1 |
| Linear Algebra I (L0914) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **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** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min (Analysis I) + 60 min (Linear Algebra I) |
| **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>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory |

| | |
|---|---|
| | Computational Science and Engineering: 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 L1010: Analysis I** | |
|---|---|
| **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** | Foundations of differential and integrational calculus of one variable<br>• statements, sets and functions<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 |
| **Literature** | • http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html |

| **Course L1012: Analysis I** | |
|---|---|
| **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 L1013: Analysis I** | |
|---|---|
| **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, Dr. Simon Campese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0912: Linear Algebra I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anusch Taraz, Dr. Dennis Clemens, Prof. Marko Lindner |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • vectors: intuition, rules, inner and cross product, lines and planes<br>• systems of linear equations: Gauß elimination, matrix product, inverse matrices, transformations, block matrices, determinants<br>• orthogonal projection in R^n, Gram-Schmidt-Orthonormalization |
| **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 L0913: Linear Algebra I | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Anusch Taraz, Dr. Dennis Clemens, Prof. Marko Lindner |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • vectors: intuition, rules, inner and cross product, lines and planes<br>• general vector spaces: subspaces, Euclidean vector spaces<br>• systems of linear equations: Gauß-elimination, matrix product, inverse matrices, transformations, LR-decomposition, block matrices, determinants |
| **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 |

| Course L0914: Linear Algebra I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Christian Seifert, Dr. Dennis Clemens |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0889: Mechanics I (Statics)

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Robert Seifried |
| **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>Data Science: Specialisation Mechanics: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br><br>Mechatronics: Core Qualification: 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 L1001: Mechanics I (Statics) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Robert Seifried |
| **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 L1002: 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. Robert Seifried |
| **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 L1003: 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. Robert Seifried |
| **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 M0577: Non-technical Courses for Bachelors

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

| | |
|---|---|
| | • to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees,<br>• to express themselves competently, in a culturally appropriate and gender-sensitive manner in the language of the country (as far as this study-focus would be chosen),<br>• to explain nontechnical items to auditorium with technical background knowledge. |
| *Autonomy* | **Personal Competences (Self-reliance)**<br>Students are able in selected areas<br>• to reflect on their own profession and professionalism in the context of real-life fields of application<br>• to organize themselves and their own learning processes<br>• to reflect and decide questions in front of a broad education background<br>• to communicate a nontechnical item in a competent way in writen form or verbaly<br>• to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen) |
| **Workload in Hours** | Depends on choice of courses |
| **Credit points** | 6 |

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

## Module 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 |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Sstudents 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>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><br>Chemie, Charles Mortimer (Deutsch und Englisch verfügbar)<br><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><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><br>Chemie, Charles Mortimer (Deutsch und Englisch verfügbar)<br><br>Analytische und anorganische Chemie, Jander/Blasius<br><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** | |
| **Literature** | |

## 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 |

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|---|---|
| **Module Responsible** | Prof. Görschwin Fey |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | |
| *Skills* | |
| **Personal Competence** | |
| *Social Competence* | |
| *Autonomy* | |
| **Workload in Hours** | Independent Study Time 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** | 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>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 to 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: 20 %; 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 |

### Course L2727: Introduction to 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 |
| **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** | Prof. Martin Kaltschmitt, Prof. Dr. Felix Ament, Prof. Dr. 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** | |

| 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** | Prof. Martin Kaltschmitt, Prof. Dr. Felix Ament, Prof. Dr. 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** | |

## Module M0851: Mathematics II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Analysis II (L1025) | Lecture | 2 | 2 |
| Analysis II (L1026) | Recitation Section (large) | 1 | 1 |
| Analysis II (L1027) | Recitation Section (small) | 1 | 1 |
| Linear Algebra II (L0915) | Lecture | 2 | 2 |
| Linear Algebra II (L0916) | Recitation Section (small) | 1 | 1 |
| Linear Algebra II (L0917) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **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** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min (Analysis II) + 60 min (Linear Algebra II) |
| **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>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computational Science and Engineering: 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 L1025: Analysis II | |
|---|---|
| **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** | SoSe |
| **Content** | • 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 |
| **Literature** | • http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html |

| Course L1026: Analysis II | |
|---|---|
| **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, Dr. Sebastian Götschel |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1027: Analysis II | |
|---|---|
| **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** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0915: Linear Algebra II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anusch Taraz, Dr. Dennis Clemens, Prof. Marko Lindner |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • 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 L0916: Linear Algebra II | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Anusch Taraz, Dr. Dennis Clemens, Prof. Marko Lindner |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • linear mappings: basis transformation, orthogonal projection, orthogonal matrices, householder matrices<br>• linear regression: QR-decomposition, normal equations, linear discrete approximation<br>• eigenvalues: diagonalising matrices, normal matrices, symmetric and Hermite matrices, Jordan normal form, singular value decomposition<br>• system of linear differential equations |
| **Literature** | • 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 |

| Course L0917: Linear Algebra II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Anusch Taraz, Dr. Christian Seifert, Dr. Dennis Clemens, Prof. Marko Lindner |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0696: Mechanics II: Mechanics of Materials

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Christian Cyron |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mechanics I |
| **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* | - |
| *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** | 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>Data Science: Specialisation Mechanics: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: 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>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: Mechanics II

| | |
|---|---|
| **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** | stresses and strains<br>Hooke's law<br>tension and compression<br>torsion<br>bending<br>stability<br>buckling<br>energy methods |
| **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 L0494: Mechanics II | |
|---|---|
| **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 |

| Course L1691: Mechanics II | |
|---|---|
| **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, Dr. Konrad Schneider |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0888: Organic Chemistry

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Organic Chemistry (L0831) | Lecture | 4 | 4 |
| Organic Chemistry (L0832) | Practical Course | 3 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralph Holl |
| **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 82, Study Time in Lecture 98 |
| **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>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory |

### Course L0831: Organic Chemistry

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Lecturer** | Prof. Nina Schützenmeister, Prof. Pierre Stallforth |
| **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** | 3 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 18, Study Time in Lecture 42 |
| **Lecturer** | Prof. Nina Schützenmeister, Prof. Pierre Stallforth |
| **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 |

## 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 are able to discuss in small groups and develop an approach. |
| *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. |
| **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>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: 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>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 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** | None |
| **Examination** | Written exam |
| **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 Production Management and Processes: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation 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. Anusch Taraz |
| **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>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: 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 Traffic Planning and Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation 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>• 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: Elective 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>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: No; Bonus: 20 %; Form: Excercises; Description: 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 Process Engineering: Compulsory<br>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** | 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>Green Technologies: Energy, Water, Climate: Core Qualification: 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 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
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 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 |
| Fossil Energy Systems (L2746) | Recitation Section (large) | 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** | 90 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 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. Martin Kaltschmitt, 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 L2746: Fossil Energy Systems | |
|---|---|
| **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** | The goal of this exercise 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 to occur in the coming years, are also discussed. In addition, the respective reserve and resource availability is illuminated. |
| **Literature** | Unterlagen des Übung |

## Module M1715: Renewable Energies

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Renewable Energies I (L2740) | Lecture | 2 | 2 |
| Renewable Energies I (L2742) | Recitation Section (large) | 1 | 1 |
| Renewable Energies II (L2741) | Lecture | 2 | 2 |
| Renewable Energies II (L2743) | Recitation Section (large) | 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 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** | 90 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 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>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory |

### 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 |

| Course L2743: Renewable Energies II | |
|---|---|
| **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** | The students work on tasks in the field of renewable energies the field "energy from biomass". They present their solution approaches in the exercise group and discuss them with their fellow students and the teaching staff afterwards. |
| **Literature** | Unterlagen der Vorlesung |

## 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) | 1 | 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 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: 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>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** | 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 |

| 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** | NN |
| **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: Core Qualification: Elective 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 Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation 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** | NN |
| **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** | NN |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## 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** | 150 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 M0757: Biochemistry and Microbiology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Biochemistry (L0351) | Lecture | 2 | 2 |
| Biochemistry (L0728) | Project-/problem-based Learning | 1 | 1 |
| Microbiology (L0881) | Lecture | 2 | 2 |
| Microbiology (L0888) | Project-/problem-based Learning | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Johannes Gescher |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | At the end of this module the students can:<br>- explain the methods of biological and biochemical research to determine the properties of biomolecules<br>- name the basic components of a living organism<br>- explain the principles of metabolism<br>- describe the structure of living cells<br>- |
| *Skills* | |
| **Personal Competence** | |
| *Social Competence* | The students are able,<br>- to gather knowledge in groups of about 10 students<br>- to introduce their own knowledge and to argue their view in discussions in teams<br>- to divide a complex task into subtasks, solve these and to present the combined results |
| *Autonomy* | The students are able to present the results of their subtasks in a written report |
| **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** | Bioprocess Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L0351: Biochemistry | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Paul Bubenheim |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. The molecular logic of Life<br>2. Biomolecules:<br>  1. Amino acids, peptides, proteins<br>  2. Carbohydrates<br>  3. Lipids<br>3. Protein functions, Enzymes:<br>  1. Michaelis-Menten kinetics<br>  2. Enzyme regulation<br>  3. Enzyme nomenclature<br>4. Cofactors and cosubstrates, vitamines<br>5. Metabolism:<br>  1. Basic principles<br>  2. Photosynthesis<br>  3. Glycolysis<br>  4. Citric acid cycle<br>  5. Respiration<br>  6. Anaerobic respirations<br>  7. Fatty acid metabolism<br>  8. Amino acid metabolism |
| **Literature** | Biochemie, H. Robert Horton, Laurence A. Moran, K. Gray Scrimeour, Marc D. Perry, J. David Rawn, Pearson Studium, München<br><br>Prinzipien der Biochemie, A. L. Lehninger, de Gruyter Verlag Berlin |

| Course L0728: Biochemistry | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Paul Bubenheim |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. The molecular logic of Life<br>2. Biomolecules:<br>  1. Amino acids, peptides, proteins<br>  2. Carbohydrates<br>  3. Lipids<br>3. Protein functions, Enzymes:<br>  1. Michaelis-Menten kinetics<br>  2. Enzyme regulation<br>  3. Enzyme nomenclature<br>4. Cofactors and cosubstrates, vitamines<br>5. Metabolism:<br>  1. Basic principles<br>  2. Photosynthesis<br>  3. Glycolysis<br>  4. Citric acid cycle<br>  5. Respiration<br>  6. Anaerobic respirations<br>  7. Fatty acid metabolism<br>  8. Amino acid metabolism |
| **Literature** | Biochemie, H. Robert Horton, Laurence A. Moran, K. Gray Scrimeour, Marc D. Perry, J. David Rawn, Pearson Studium, München<br><br>Prinzipien der Biochemie, A. L. Lehninger, de Gruyter Verlag Berlin |

| **Course L0881: Microbiology** | |
|---|---|
| **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** | SoSe |
| **Content** | 1. The procaryotic cell<br>• evolution<br>• taxonomy and specific properties of Archaea, Bacteria, and viruses<br>• structure and properties of the cell<br>• growth<br>2. Metabolism<br>• fermentation and anaerobic respiration<br>• methanogenesis and the anaerobic food chain<br>• degradation of polymers<br>• chemolithotrophy<br>3. Microorganisms in relation to the environment<br>• chemotaxis and motility<br>• Elemental cycle of carbon, nitrogen and sulfur<br>• biofilms<br>• symbiotic relationships<br>• extremophiles<br>• biotechnology |
| **Literature** | • **Allgemeine Mikrobiologie**, 8. Aufl., 2007, Fuchs, G. (Hrsg.), Thieme Verlag (54,95 €)<br>• **Mikrobiologie**, 13 Aufl., 2013, Madigan, M., Martinko, J. M., Stahl, D. A., Clark, D. P. (Hrsg.), ehemals „Brock“, Pearson Verlag (89,95 €)<br>• Taschenlehrbuch Biologie **Mikrobiologie**, 2008, Munk, K. (Hrsg.), Thieme Verlag<br>• **Grundlagen der Mikrobiologie**, 4. Aufl., 2010, Cypionka, H., Springer Verlag (29,95 €), http://www.grundlagen-der-mikrobiologie.icbm.de/ |

| **Course L0888: Microbiology** | |
|---|---|
| **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** | SoSe |
| **Content** | 1. The procaryotic cell<br>• evolution<br>• taxonomy and specific properties of Archaea, Bacteria, and viruses<br>• structure and properties of the cell<br>• growth<br>2. Metabolism<br>• fermentation and anaerobic respiration<br>• methanogenesis and the anaerobic food chain<br>• degradation of polymers<br>• chemolithotrophy<br>3. Microorganisms in relation to the environment<br>• chemotaxis and motility<br>• Elemental cycle of carbon, nitrogen and sulfur<br>• biofilms<br>• symbiotic relationships<br>• extremophiles<br>• biotechnology |
| **Literature** | • **Allgemeine Mikrobiologie**, 8. Aufl., 2007, Fuchs, G. (Hrsg.), Thieme Verlag (54,95 €)<br>• **Mikrobiologie**, 13 Aufl., 2013, Madigan, M., Martinko, J. M., Stahl, D. A., Clark, D. P. (Hrsg.), ehemals „Brock“, Pearson Verlag (89,95 €)<br>• Taschenlehrbuch Biologie **Mikrobiologie**, 2008, Munk, K. (Hrsg.), Thieme Verlag<br>• **Grundlagen der Mikrobiologie**, 4. Aufl., 2010, Cypionka, H., Springer Verlag (29,95 €), http://www.grundlagen-der-mikrobiologie.icbm.de/ |

## 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 |

| | |
|---|---|
| **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>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 of rate laws, Damköhler-number, differential and integral method of kinetic analysis, laboratory reactors for kinetic measurements, |

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| | 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, enthalpy, calorimeter, heat of reaction, standard heat of formation, Hess law, heat capacity, Kirchhoff law, standard heat of |

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|---|---|
| | 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 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 |

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|---|---|
| **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>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 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 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. |
| **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 M0945: Bioprocess Engineering - Advanced

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Bioprocess Engineering - Advanced (L1107) | Lecture | 2 | 4 |
| Bioprocess Engineering - Advanced (L1108) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf Pörtner |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Content of module "Biochemisty and Microbiology"<br>Content of module "Biochemical Engineering I" |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After successful completion of this module, students should be able<br>- explain the microbial, energetic and engineering principles of fermentation process,<br>- explain different kinetic approaches for cell growth, substrate uptake and product formation and apply them for process development,<br>- understand and quantify transport phenomena in bioreactor and consider them for bioprocess scale-up<br>- identify specific scientific problems and solutions for different types of fermentation processes |
| *Skills* | After successful completion of this module, students should be able to<br>- to identify scientific questions or possible practical problems for concrete industrial applications (eg cultivation of microorganisms and animal cells) and to formulate solutions ,<br>- to assess the application of scale-up criteria for different types of bioreactors and processes and to apply these criteria to given problems (anaerobic , aerobic or microaerobic bioprocesses),<br>- to formulate questions for the analysis and optimization of real biotechnological production processes appropriate solutions,<br>- to describe the effects of the energy generation, the regeneration of reduction equivalents , and the growth inhibition of the behavior of microorganisms and to the total fermentation process qualitatively,<br>- to establish material balance and fermentation equations and solve them to determine the kinetic parameters of different approaches,<br>- to select process control strategies (batch , fed-batch ,or continuous culture) appropriately and to calculate basic types and evaluate them. |
| **Personal Competence** | |
| *Social Competence* | After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork. |
| *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 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** | Bioprocess Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L1107: Bioprocess Engineering - Advanced | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Pörtner, Prof. Andreas Liese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction: state-of-the-art and development trends of microbial and biocatalytic bioprocesses, introduction to the lecture<br>• Microbial principles of fermentation, Energetic fundamentals of bioreaction<br>• Medium design and optimization, sterilization<br>• Kinetics of cell growth<br>• Kinetics of substrate consumption and product formation<br>• Material balances and metabolic flux analysis<br>• Transport phenomena in bioreactor and bioprocess scale-u<br>• Anaerobic fermentation process, integrated downstream processin<br>• Microaerobic bioprocess: optimal O2 supply, process control and scale-u<br>• Aerobic process and high cell density culture<br>• Problem-based learning with selected bioprocesses |
| **Literature** | P. F. Stanbury, A. Whitaker, S. J. Hall, Principles of Fermentation Technology, 3 rd. Edition, Butterworth-Heinemann, 2016.<br>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006<br>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010<br>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997<br>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013<br>Skripte für die Vorlesung |

| Course L1108: Bioprocess Engineering - Advanced | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Pörtner, Prof. Andreas Liese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction: state-of-the-art and development trends of microbial and biocatalytic bioprocesses, introduction to the lecture<br>• Microbial principles of fermentation, Energetic fundamentals of bioreaction<br>• Medium design and optimization, sterilization<br>• Kinetics of cell growth<br>• Kinetics of substrate consumption and product formation<br>• Material balances and metabolic flux analysis<br>• Transport phenomena in bioreactor and bioprocess scale-u<br>• Anaerobic fermentation process, integrated downstream processin<br>• Microaerobic bioprocess: optimal O2 supply, process control and scale-u<br>• Aerobic process and high cell density culture<br>• Problem-based learning with selected bioprocesses<br>The students present exercises and discuss them with their fellow students and faculty statt. In the PBL part of the class the students discuss scientific questions in teams. They acquire knowledge and apply it to unknown questions, present their results and argue their opinions. |
| **Literature** | P. F. Stanbury, A. Whitaker, S. J. Hall, Principles of Fermentation Technology, 3 rd. Edition, Butterworth-Heinemann, 2016.<br>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006<br>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010<br>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013<br>Skripte für die Vorlesung |

## Module M0539: Process and Plant Engineering I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Process and Plant Engineering I (L0095) | Lecture | 2 | 4 |
| Process and Plant Engineering I (L0096) | Recitation Section (large) | 1 | 1 |
| Process and Plant Engineering I (L1214) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Mirko Skiborowski |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | unit operation of thermal an dmechanical separation processes<br>chemical reactor eingineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | students can:<br>classify and formulate blobal balance equations of chemical processes<br>specify linear component equations of complex chemical processes<br>explain linear regression and data reconcilliation problems<br>explain pfd-diagrams |
| *Skills* | students are capable of<br>- formulation of mass and energy balance equations and estimation of product streams<br>- estimation of component streams of chemical plants using linear component balance models<br>- solution of data reconcilliation tasks<br>- conduction of process synthesis<br>- economic evaluation of processes and the estimation of production costs |
| **Personal Competence** | |
| *Social Competence* | Students are able to work together in heterogeneous small groups to find solutions. |
| *Autonomy* | Students are able to gain knowledge from further literature on the subject. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: Yes; Bonus: 10 %; Form: Subject theoretical and practical work; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 Min. lectures notes and books |
| **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>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

### Course L0095: Process and Plant Engineering I

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Mirko Skiborowski |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. **Introduction**<br>Structure and operation of production plants<br>Operational business process<br>Technical process design<br>Motivation and targets of process development<br>Life cycle of production plants<br>2. **Engineering methods and tools**<br>Mass and energy balances<br>Strategies of process synthesis<br>Graphical representation of processes<br>Multidimensional regression<br>Data reconciliation and data validation<br>3. **Process Synthesis**<br>Decision levels |

| | |
|---|---|
| | Experimental process development<br>Reactor synthesis<br>Synthesis of separation processes (process alternatives and criteria for selection)<br>Integration of reaction systems/separation systems (interactions, recycle streams)<br>4. **Process safety**<br>5. **Cost estimation of production plants**<br>Production costs, capital costs, economic evaluation |
| **Literature** | S.D. Barnicki, J.R. Fair, Ind. End. Chem., 29(1990), S. 421, Ind. End. Chem., 31(1992), S. 1679<br>H. Becker, S. Godorr, H. Kreis, Chemical Engineering, January 2001, S. 68-74<br>Behr, W. Ebbers, N. Wiese, Chem. -Ing.-Tech. 72(2000)Nr. 10, S.1157<br>E. Blass, Entwicklung verfahrenstechnischer Prozesse, Springer-Verlag, 2. Auflage 1997<br>M. H. Bauer, J. Stichlmair, Chem.-Ing.-Tech., 68(1996), Nr. 8, 911-916<br>R. Dittmeyer, W. Keim, G. Kreysa, A. Oberholz, Chemische Technik. Prozesse und Produkte,<br>Band 2, Neue Technologien, 5. Auflage, Wiley-VCH GmbH&Co.KGaA, Weinheim, 2004<br>J.M. Douglas, Conceptual Design of Chemical Processes, Mc Graw-Hill, NY, 1988<br>G. Fieg, Inz. Chem. Proc., 5(1979), S.15-19<br>G. Fieg, G. Wozny, L. Jeromin, Chem. Eng. Technol. 17(1994),5, 301-306<br>G. Fieg, Heat and Mass Transfer 32(1996), S. 205-213<br>G. Fieg, Chem. Eng. Processing, Vol. 41/2(2001), S. 123-133<br>U.H. Felcht, Chemie eine reife Industrie oder weiterhin Innovationsmotor, Universitätsbuchhandlung Blazek und Bergamann, Frankfurt, 2000<br>J.P. van Gigch, Systems Design, Modeling and Metamodeling, Plenum Press, New York, 1991<br>T.F. Edgar, D.M. Himmelblau, L.S. Lasdon, Optimization of Chemical Processes, McGraw-Hill, 2001<br>G. Gruhn, Vorlesungsmanuskript „Prozess- und Anlagentechnik, TU Hamburg-Harburg<br>D. Hairston, Chemical Engineering, October 2001, S. 31-37<br>J.L.A. Koolen, Design of Simple and Robust Process Plants, Wiley-VCH, Weinheim, 2002<br>J. Krekel, G. Siekmann, Chem. -Ing.-Tech. 57(1985)Nr. 6, S. 511<br>K. Machej, G. Fieg, J. Wojcik, Inz. Chem. Proc., 2(1981), S.815-824<br>S. Meier, G. Kaibel, Chem. -Ing.-Tech. 62(1990)Nr. 13, S.169<br>J. Mittelstraß, Chem. -Ing.-Tech. 66(1994), S. 309<br>P. Li, M. Flender, K. Löwe, G. Wozny, G. Fieg, Fett/Lipid 100(1998), Nr. 12, S. 528-534<br>G. Kaibel, Dissertation, TU München, 1987<br>G. Kaibel, Chem.-Ing.-Tech. 61 (1989), Nr. 2, S. 104-112<br>G. Kaibel, Chem. Eng. Technol., 10(1987), Nr. 2, S. 92-98<br>H.J. Lang, Chem. Eng. 54(10),117, 1947<br>H.J. Lang, Chem. Eng. 55(6), 112, 1948<br>F. Lestak, C. Collins, Chemical Engineering, July 1997, S. 72-76 |

| **Course L0096: Process and Plant 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. Mirko Skiborowski, Dr. Thomas Waluga |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1214: Process and Plant Engineering I | |
|---|---|
| **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, Dr. Thomas Waluga |
| **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>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: 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 M0938: Bioprocess Engineering - Fundamentals

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Bioprocess Engineering - Fundamentals (L0841) | Lecture | 2 | 3 |
| Bioprocess Engineering- Fundamentals (L0842) | Recitation Section (large) | 2 | 1 |
| Bioprocess Engineering - Fundamental Practical Course (L0843) | Practical Course | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Andreas Liese |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | module "organic chemistry", module "fundamentals for process engineering" |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail. |
| *Skills* | After successful completion of this module, students should be able to<br>• describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters<br>• predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentation process<br>• analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations<br>• distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compare them as well as to apply them to current biotechnical problem<br>• propose solutions to complicated biotechnological problems and to deduce the corresponding models<br>• to explore new knowledge resources and to apply the newly gained contents<br>• identify scientific problems with concrete industrial use and to formulate solutions.<br>• to document and discuss their procedures as well as results in a scientific manner |
| **Personal Competence** | |
| *Social Competence* | After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments. |
| *Autonomy* | After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum. |
| **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** | Bioprocess Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0841: Bioprocess Engineering - Fundamentals | |
|---|---|
| **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** | SoSe |
| **Content** | • Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture<br>• Enzyme kinetics: Michaelis-Menten, differnt types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese)<br>• Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese)<br>• Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng)<br>• Kinetic of subtrate consumption and product formation (Prof. Zeng)<br>• Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese)<br>• Transport process in a bioreactor (Prof. Zeng)<br>• Technology of sterilization (Prof. Zeng)<br>• Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuouse bioprocesses (Prof. Zeng/Prof. Liese)<br>• Downstream technology in biotechnology: cell breakdown, zentrifugation, filtration, aqueous two phase systems (Prof. Liese) |
| **Literature** | K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012<br><br>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006<br><br>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010<br><br>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997<br><br>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013 |

| Course L0842: Bioprocess Engineering- Fundamentals | |
|---|---|
| **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** | SoSe |
| **Content** | 1. Introduction (Prof. Liese, Prof. Zeng)<br><br>2. Enzymatic kinetics (Prof. Liese)<br><br>3. Stoichiometry I + II (Prof. Liese)<br><br>4. Microbial Kinetics I+II (Prof. Zeng)<br><br>5. Rheology (Prof. Liese)<br><br>6. Mass transfer in bioprocess (Prof. Zeng)<br><br>7. Continuous culture (Chemostat) (Prof. Zeng)<br><br>8. Sterilisation (Prof. Zeng)<br><br>9. Downstream processing (Prof. Liese)<br><br>10. Repetition (Reserve) (Prof. Liese, Prof. Zeng) |
| **Literature** | siehe Vorlesung |

| Course L0843: Bioprocess Engineering - 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** | SoSe |
| **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** | Skript |

## 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 |
| **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>Computer Science: Core Qualification: 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>Mechatronics: Specialisation Naval Engineering: Compulsory |

| | |
|---|---|
| | Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Medical 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. Christian Lüthje, Prof. Christian Ringle, Prof. Christoph Ihl, Prof. Cornelius Herstatt, Prof. Kathrin Fischer, Prof. Matthias Meyer, Prof. Thomas Wrona, Prof. Thorsten Blecker, 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 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 Electrical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical 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: Elective Compulsory<br>Logistics and Mobility: Specialisation Information Technology: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation 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>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>Data Science: Core Qualification: 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>Renewable Energies: Core Qualification: 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<br>• power economy fundamentals |
| **Literature** | K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013<br><br>A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017<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", Vieweg + Teubner, 9. Auflage, 2013<br><br>A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017<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 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. |
| **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 M1745: Climate physics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Climate physics (L2833) | Lecture | 2 | 3 |
| Climate physics (L2834) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Dr. Stefan Bühler |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | - obligatory: none<br>- Recommended: basic knowledge of mathematics and physics acquired in the beginning semesters and knowledge from Introduction to Meteorology. Expertise in climate physics and statistics is not required. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The lecture "Climate Physics" starts with the definition of the terms climate and climate system. Then other important terms such as climate forcing and climate feedback are clarified. We then examine the Earth's radiative budget, which ultimately determines climate. Chapter 3 deals with the central issue of climate sensitivity, how much does the planet warm for a given radiative forcing? This leads to the important topic of climate feedbacks, which are discussed in the following chapters: Water Vapor, Temperature Gradient, and Ice Albedo in Chapter 4, then Clouds and Biosphere in Chapter 5. Chapter 6 deals with the Ocean and Cryosphere subsystems and their role in the climate system. Then comes the topic of material cycles in chapter 7, with a particular focus on the cycles of water and carbon. The carbon cycle provides a natural perspective on the entire Earth system history, the topic of the eighth and last lecture chapter. In the exercises the acquired knowledge is used to solve simple problems. |
| *Skills* | The students are familiar with the basic thinking and methods of climate physics and meteorological statistics. They know the importance of the different climate system components in the climate system and have understood the material cycles in the climate system (water, carbon cycle). They are able to qualitatively record processes in the climate system (trends, fluctuations). They are familiar with the basic methods of climate system analysis and know which model types can be used to describe the dynamics of the climate system. |
| **Personal Competence** | |
| *Social Competence* | Students will be able to discuss problems in the topics of climate physics 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 physical effects related to climate on their own. |
| **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** | Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory |

### Course L2833: Climate physics

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dr. Stefan Bühler |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | In the first chapter, we clarify important terms such as climate, climate system, climate forcing, and climate feedback. We then examine the Earth's radiative budget, which ultimately determines climate. Chapter 3 deals with the central issue of climate sensitivity, how much does the planet warm for a given radiative forcing? This leads to the important topic of climate feedbacks, which are discussed in the following chapters: Water Vapor, Temperature Gradient, and Ice Albedo in Chapter 4, then Clouds and Biosphere in Chapter 5. Chapter 6 deals with the Ocean and Cryosphere subsystems and their role in the climate system. Then comes the topic of material cycles in Chapter 7, focusing primarily on the cycles of water and carbon. From the carbon cycle comes a natural perspective on the overall Earth system history, the topic of the eighth and final lecture chapter.<br><br>**Learning Objective:**<br>This lecture provides a basic understanding of the physics of the climate system and the dynamics of the climate system throughout Earth history. |
| **Literature** | **Literatur**:<br>Dennis Hartmann, Global Physical Climatology (2nd Edition), Elsevier, 2016<br>Raymond Pierrehumbert, Principles of Planetary Climate, Cambridge University Press, 2010<br>Wallace, J. M., & Hobbs, P. V. 2006, Atmospheric science: an introductory survey (2nd Edition), Academic press.<br>Peixoto and Oort, Physics of Climate, AIP, 1992 |

| Course L2834: Climate physics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dr. Stefan Bühler |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## 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. Dr. 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>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: 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 |
| **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>Computer Science: Core Qualification: 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>Mechatronics: Specialisation Naval Engineering: Compulsory |

| | |
|---|---|
| | Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Medical 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. Christian Lüthje, Prof. Christian Ringle, Prof. Christoph Ihl, Prof. Cornelius Herstatt, Prof. Kathrin Fischer, Prof. Matthias Meyer, Prof. Thomas Wrona, Prof. Thorsten Blecker, 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 |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: 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 |

| 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. Dr. 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. Dr. Nikola Bursac, Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## 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>Logistics and Mobility: Specialisation Engineering Science: 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 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** | SoSe |
| **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 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 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. |
| **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

**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 Mechatronics: Compulsory
Engineering Science: Specialisation Mechanical Engineering: Compulsory
Engineering Science: Specialisation Biomedical Engineering: 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 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>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 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 Mechatronics: 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>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Engineering Science: Specialisation Electrical Engineering: 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 Traffic Planning and Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation 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>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: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Elective Compulsory<br>Mechatronics: Specialisation Medical Engineering: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation 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, 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, 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 |
| **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>Computer Science: Core Qualification: 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>Mechatronics: Specialisation Naval Engineering: Compulsory |

| | |
|---|---|
| | Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Medical 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. Christian Lüthje, Prof. Christian Ringle, Prof. Christoph Ihl, Prof. Cornelius Herstatt, Prof. Kathrin Fischer, Prof. Matthias Meyer, Prof. Thomas Wrona, Prof. Thorsten Blecker, 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><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><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><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 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** | SoSe |
| **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 shipo design and safety of ships. |
| *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* | The student gets access to hydrostatical problems. |
| *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 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<br>3. Stability at large heeling angles<br>- Stability Equation<br>- Cross Curves of Stability and Righting Levers<br>- Numerical and Graphical Determination of Cross Curves<br>- Heeling Moments of Free Surfaces, Water on Deck, Water Ingress<br>- Heeling Moments of Different Type<br>- Balance of Heeling and Righting Moments acc. to BV 1030<br>- Intact Stability Code (General Critaria)<br>4. Linearization of Stability Problems |

| | |
|---|---|
| | - Linearization of Restoring Forces and Moments<br>- Correlation between Metacentric Height and Righting Lever at small heeling angles<br>- Computation of Path of Metacentric Height for Modern Hull Forms<br>- Correlation between Righting Lever and Path of Metacentric Height<br>- Hydrostatic Stiffness Matrix<br>- Definition of MCT<br>- Computation of Equilibrum Floating Conditions from Hydrostatic Tables<br>- Effect of Free Surfaces on Initial GM<br>- Roll Motions at Small Roll Angles<br>6. Stability in Waves<br>- Roll Motions at Large Amplitudes<br>- Pure Loss of Stability on the Wave Crest<br>- Principle of Parametric Excitation<br>- Principle of Direct Wave Moments<br>- Grim´s Equivalent Wave Concept<br>6 Longitudinal Strength<br>- Longitudinal Mass Distribution, Shear Forces, Bending Moments<br>- Longitudinal Strength in Stability Booklet<br>7. Deadweight Survey and Inclining Experiment<br>- Deplacement Computations from Draft mark Readings<br>- Weights to go on /come from board<br>- Inclining Experiment with Heeling Moments from Weights and Heeling Tanks<br>- Residual Sounding Volumes<br>- Determination of COG from Metacentric height and from Cross Curves<br>- Roll Decay Test<br>8. Launching and Docking<br>- Launching Plan, Arrangement of Launching Blocks<br>- Rigid Body Launching: Tilting, Dumping, Equation of Techel<br>- Computation of Launching Event<br>- Bottom Pressure and Longitudinal Strength<br>- Linear- Elastic Effects<br>- Transversal Stability on Slipway and in Dock<br>9. Grounding<br>- Loss of Buoynacy when Grounded<br>- Pointwise Grounding<br>- Ship Grounds on Keel<br>10. Introduction into Damage Stability Problems<br>- Added Mass Method<br>- Loss of Buoyant Volume Method<br>- 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 |

| | |
|---|---|
| | 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><br>- Grid<br><br>- approx. 20 sections, 5 Waterlines, 5 Buttocks<br><br>- Computation Volume and centre of buoyancy for several drafts<br><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 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>Data Science: Core Qualification: Elective 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 Dynamic Systems and AI: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Medical Engineering: 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 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 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 Mechatronics: 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>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Engineering Science: Specialisation Electrical Engineering: 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 Traffic Planning and Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation 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 |
| **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>Engineering Science: Specialisation Mechatronics: 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 Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation 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. Dr. 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. Dr. 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 |
| **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>Computer Science: Core Qualification: 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>Mechatronics: Specialisation Naval Engineering: Compulsory |

| | |
|---|---|
| | Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Medical 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. Christian Lüthje, Prof. Christian Ringle, Prof. Christoph Ihl, Prof. Cornelius Herstatt, Prof. Kathrin Fischer, Prof. Matthias Meyer, Prof. Thomas Wrona, Prof. Thorsten Blecker, 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 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** | |
| **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** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | ? |
| **Assignment for the Following Curricula** | Green Technologies: Energy, Water, Climate: Specialisation Water: 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 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* | |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**: Yes / None / Presentation / 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: 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 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 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. |
| **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>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 |
|---|---|---|---|
| Nature-oriented Hydraulic Engineering (L2472) | Project-/problem-based Learning | 2 | 2 |
| Numerical modelling of soil water dynamics (L2471) | Project-/problem-based Learning | 2 | 2 |
| Numerical modelling of soil water dynamics (L2470) | Lecture | 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 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** | • 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** | |

### Course L2471: Numerical 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: Numerical 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** | Dr. Milad Aminzadeh |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Hydrologic water bilance<br>• aquifertyps<br>• groundwater velocities<br>• Darcy law<br>• groundwater contour lines<br>• storage capacity<br>• flow equation<br>• pumping tests<br>• method of Beyer<br>• solute transport in groundwater<br>• Basics and theoretical background of simulation methods for the analysis of water movement in vadose zone<br>• groundwater recharge |
| **Literature** | Todd, K. (2005): Groundwater Hydrology<br><br>Fetter, C. W. (2001): Applied Hydrogeology<br><br>Hölting, B. & Coldewey, W. (2005): Hydrogeologie<br><br>Charbeneau, R. J. (2000): Groundwater Hydraulics and pollutant Transport |

## 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 |
| **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>Computer Science: Core Qualification: 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>Mechatronics: Specialisation Naval Engineering: Compulsory |

| | |
|---|---|
| | Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Medical 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. Christian Lüthje, Prof. Christian Ringle, Prof. Christoph Ihl, Prof. Cornelius Herstatt, Prof. Kathrin Fischer, Prof. Matthias Meyer, Prof. Thomas Wrona, Prof. Thorsten Blecker, 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 M-001: Bachelor Thesis

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Professoren der TUHH |
| **Admission Requirements** | • According to General Regulations §21 (1):<br>At least 126 ECTS credit points have to be achieved in study programme. The examinations board decides on exceptions. |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • The students can select, outline and, if need be, critically discuss the most important scientific fundamentals of their course of study (facts, theories, and methods).<br>• On the basis of their fundamental knowledge of their subject the students are capable in relation to a specific issue of opening up and establishing links with extended specialized expertise.<br>• The students are able to outline the state of research on a selected issue in their subject area. |
| *Skills* | • The students can make targeted use of the basic knowledge of their subject that they have acquired in their studies to solve subject-related problems.<br>• With the aid of the methods they have learnt during their studies the students can analyze problems, make decisions on technical issues, and develop solutions.<br>• The students can take up a critical position on the findings of their own research work from a specialized perspective. |
| **Personal Competence** | |
| *Social Competence* | • Both in writing and orally the students can outline a scientific issue for an expert audience accurately, understandably and in a structured way.<br>• The students can deal with issues in an expert discussion and answer them in a manner that is appropriate to the addressees. In doing so they can uphold their own assessments and viewpoints convincingly. |
| *Autonomy* | • The students are capable of structuring an extensive work process in terms of time and of dealing with an issue within a specified time frame.<br>• The students are able to identify, open up, and connect knowledge and material necessary for working on a scientific problem.<br>• The students can apply the essential techniques of scientific work to research of their own. |
| **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): Thesis: Compulsory<br>General Engineering Science (German program, 7 semester): Thesis: Compulsory<br>Civil- and Environmental Engineering: Thesis: Compulsory<br>Bioprocess Engineering: Thesis: Compulsory<br>Chemical and Bioprocess Engineering: Thesis: Compulsory<br>Computer Science: Thesis: Compulsory<br>Data Science: Thesis: Compulsory<br>Digital Mechanical Engineering: Thesis: Compulsory<br>Electrical Engineering: Thesis: Compulsory<br>Engineering Science: Thesis: Compulsory<br>General Engineering Science (English program): Thesis: Compulsory<br>General Engineering Science (English program, 7 semester): Thesis: Compulsory<br>Green Technologies: Energy, Water, Climate: Thesis: Compulsory<br>Computer Science in Engineering: Thesis: Compulsory<br>Integrated Building Technology: Thesis: Compulsory<br>Logistics and Mobility: Thesis: Compulsory<br>Mechanical Engineering: Thesis: Compulsory<br>Mechatronics: Thesis: Compulsory<br>Naval Architecture: Thesis: Compulsory<br>Technomathematics: Thesis: Compulsory<br>Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory<br>Process Engineering: Thesis: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Thesis: Compulsory |