TUHH
Technische Universität Hamburg-Harburg

# Module Manual

Bachelor of Science

# Energy and Environmental Engineering

Cohort: Winter Term 2017

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# Program description

## Content

One of the main challenges in modern society is the reliable, environmentally benign and sustainable supply of energy. An efficient energy supply is moreover essential to secure the economic future of the country.

The exponential increase in world population, the raised living standards and the continuously increasing hunger for feedstocks, acreage and energy make the sustainable handling of natural resources imperative. This includes the reduction of emissions and the minimization of environmental impact. An example with growing significance is the control of the $CO_2$ emissions that are responsible for the greenhouse effect. For this, possibilities are sought after that bring energy savings or involve increased use of renewable energy sources. In a continued utilization of fossil fuels the reduction of $CO_2$ emissions is pursued by increasing efficiency and also through separation and underground storage of the $CO_2$ emitted. The latter approaches make a close cooperation between Energy Engineering and Environmental Engineering unavoidable.

The consecutive degree in Energy and Environmental Engineering had been started already in the beginning of the century in the form of a corresponding Diploma course. The motivation for this development was on the one hand the increasing significance of environmental protection through $CO_2$ separation in large power stations and, on the other, the growing supply of electricity from regenerative energy sources. Both these key developments in electricity generation are taken into consideration in designing the Bachelor course. Not only for the $CO_2$ separation technologies but also for other environmental protection purposes, as for example air pollution protection, a wide spectrum of chemistry lectures is incorporated and this contrasts markedly the classical power station engineering curriculum. Renewable electricity generation is covered in the Bachelor degree from a generalist viewpoint only. First in the Master degree of Energy and Environmental Engineering special renewable energy topics are included, to expand the conventional energy systems engineering curriculum. At Master level and in addition to the above mentioned air pollution prevention, also the environmental protection of water and soils are covered.

The Bachelor of Energy and Environmental Engineering conveys a wide and well-founded multidisciplinary fundamental knowledge in the disciplines of Energy Engineering and of Environmental Engineering. This includes a well-grounded understanding over the basic methods of engineering (mathematics, mechanics, thermodynamics, fluid mechanics, chemistry, process engineering, materials engineering and engineering construction). Moreover, basic skills in environmental assessment and environmental technology and particle technology, along with non-technical subjects, are conveyed. These provide necessary qualifications for elaborating the supporting processes during system development. At the skills level the Bachelor degree prepares the student for a Master study or even a PhD research, too, so that after graduation also professional qualifications suitable for a potential future research career are gained.

## Career prospects

The operating conditions of the energy market and the environmental protection are subjected to increasingly accelerating changes. To account for this in the degree study, special attention is given to convey future-proof knowledge. This enables the students to be easily adaptable to market changes, so that also in future developments they can react autonomously, adapt successfully to their desired placement targets and extend their professional horizons independently. Towards this aim the Bachelor of Energy and Environmental Engineering covers a wide scientific and methodological basis curriculum.

The graduates, after completion of the study program, possess a wide spectrum of fundamental knowledge in the subject areas of energy systems and environmental engineering. They are thus in a position to articulate the fundamental principles of modelling and simulating energy conversion systems encompassing energy, mass and momentum transport processes, while they pay particular attention to sustainability. The graduates are able to analyze energy processes, evaluate the energetically and economically optimal operation of energy systems, draw balances of energy plants and comprehend the technical and economic interplay between conventional and renewable energy technologies. The graduates are in a position to describe the construction, operation and organization of power plants and to explain the constructive characteristics of energy systems and their components. They can also master the automatic control measures used. They can identify the environmental impact in general and develop specific strategies for mitigating the various environmental risks emanating from industrial plant. The students obtain practice in critically studying a problem of their discipline, classify it within their subject area and orally elaborate suitable solution procedures.

The graduates are in a position to undertake responsibly engineering tasks in various activity fields within energy and environmental engineering and carry them out competently. They are allowed to use the professional title “Ingenieur/Ingenieurin“ in accordance with the legal framework (IngG) of the German Federal Lands. They furthermore acquire the necessary scientific knowledge for a subsequent, deeper Master study.

Continuous interaction with Industry within the framework of joint research or through further contact opportunities enables to closely follow the increasingly accelerating changes in qualification profiling demanded by the market. This facilitates the continuous adjustment of the curricular contents of the Bachelor of Energy and Environmental Engineering to the prevailing market conditions.

## Learning target

The Bachelor of Energy and Environmental Engineering endeavors to give to the graduate not only a professional qualification but also prepare the student for a consecutive Master study program. The essential basic methodological skills to do this are conveyed through a combination of basic and advanced learning modules from Mechanical Engineering, Process Engineering and Environmental Engineering.

Through contributions in the lectures by professional engineers from industry, by using software tools established in the praxis for performing simplified tutorials or by means of on-site visits, the students are able to acquire during their study a realistic overview of the multifaceted professional field of Energy and Environmental Engineering. This strengthens the future career chances of the graduates substantially. The possibility to perform external Bachelor thesis work offers an additional exposure to real professional practice.

The graduates can undertake engineering tasks in various fields of activity in energy and environmental engineering and complete them responsibly and competently. In addition, they acquire the necessary scientific skills for a subsequent more focused Master study.

**Knowledge**

The background knowledge acquired during the Bachelor study program enables the graduate to understand phenomena incurring in Energy Systems, Environmental Engineering or neighboring disciplines. The graduates learn the basic principles of energy and environmental technology for modelling and simulating the energy conversion and the energy, matter and momentum transfer processes involved, while taking also into account sustainability and environmental protection. Their knowledge consists of facts, basic methods and theories, which are conveyed during the Bachelor of Energy and Environmental Engineering in the following manner:

- The graduates are able to articulate their basic knowledge in subject areas of the natural and engineering sciences such as mathematics, chemistry, mechanics, thermodynamics, fluid mechanics, informatics, materials science, electrical engineering and construction engineering.
- The graduates can utilize basic methods and solution approaches for iterative decision making and optimization of problems, such as differentiation, gradient based approaches or hypothesis testing. They can also analyze and evaluate the above methods as regards complexity, convergence and merit.
- Through further specialized knowledge in the subject areas (Process Engineering, Energy Systems and Environmental Technology) the graduates can describe and compare different layouts of energy processes. This applies to both conventional and renewable energy plants. They can also evaluate the environmental impact from these energy facilities.
- The graduates can describe the structure, operation and organization of conventional and regenerative energy plants and their components. This includes also the automatic control systems used therein. They are competent to identify the facets for an energetically and economically optimal operation of energy systems, while also considering the additional criteria for conserving resources and enabling sustainability, environmental compatibility and cost effectiveness.

- The graduates are familiarized with the situation from the professional life for having to choose between technical alternatives, in order to minimize the environmental and social footprint of their engineering activities and so contribute effectively to the Energy Transition.
- The graduates are capable to extend their knowledge and expand their professional competencies beyond the purely technical level, through non-technical lectures.

**Skills**

In the Bachelor study program of Energy and Environmental Engineering the skill of using learnt knowledge to solve specific problems is strengthened in various ways:

- The graduates master appropriate and subject relevant methods and tools, they appraise their computing ability and complexity and can put into practice appropriate programming tools.
- The students are in a position to map a general description for a partial problem within their discipline or a neighboring subject area, and can select appropriate methods for problem solving.
- The graduates possess the ability to understand and further analyze energy processes, draw balances in energy systems and identify technical and economic relationships between conventional and renewable energy technologies.
- The graduates can identify and describe in general the environmental impact and develop control strategies to relieve the environmental pressures from industrial plant. To this ability contribute also acquired skills from the neighboring disciplines of measurement technology and process and environmental engineering.
- The graduates are competent to identify the goals of an energy technical project, a plant or the society as a whole, aimed at satisfying the energy demand in a balanced and sustainable manner. They can set priorities responsibly and select the optimal problem solution approaches.
- The graduates can present their solution procedure and results in writing and explain them orally. They master presentation techniques and have obtained practice in technical communication.
- The graduates are capable to plan and conduct autonomously experiments, and interpret the results obtained.
- The graduates can apply measurement, control and regulation techniques or use construction methods.
- The graduates are proficient in sketching processes, machines and apparatuses that fulfill set specifications.

**Social Skills**

Social competence includes the individual ability and desire to work together with others in achieving set targets, to consider the interests of others, to express oneself clearly, and ultimately to contribute to the common work and living environments.

- The graduates can find themselves within a disciplinary homogeneous team, work out a solution approach, undertake specific partial tasks and deliver responsibly part results. They can also deliberate on their own contribution.
- The graduates are in a position to discuss the results of their scientific work interactively and multidisciplinary, to present them to an audience and defend them.
- The graduates are able to communicate with specialists and the public on contents and problems in energy and environmental engineering.

**Autonomy**

The interpersonal skills encompass, beyond autonomous handling, also the ability to further develop one's own capacity to act.

- The graduates can investigate independently a narrowly focused part of energy and environmental engineering and summarize in a seminar the results in detail, using current presentation techniques or a multi-page essay. During these assignments they are required to exercise critical analysis and not merely rote learning.
- The graduates can assess their own pre-existing competencies realistically and by themselves reverse deficiencies.
- The graduates can organize and perform projects autonomously.
- The graduates are in a position to carry out confined technical partial projects, by applying stand-alone the skills acquired during the study, in the framework of a Bachelor thesis.
- The graduates are able to acquire alone necessary information from suitable literature sources and assess its quality.
- The graduates are in a position to contemplate technical issues in a broader social context and appraise the non-technical impact of their engineering actions.

## Program structure

The curriculum of the Bachelor of Energy and Environmental Engineering, which is received as a first degree, contains mainly compulsory lectures. Optional choices are allowed within the supplementary courses of the non-technical fields.

The structure of the degree is:

- Mathematical and scientific fundamentals (six modules)
- Engineering fundamentals (eleven modules)
- Energy and environmental engineering subjects (five modules)
- Engineering applications (three modules).

Additionally, the following non-technical contents are included:

- one module on management
- Further supplementary lectures from the list of non-technical options (one module)
- The Bachelor thesis in the $6^{th}$ semester.

In this manner the Bachelor of Energy and Environmental Engineering comprises 28 Modules split into 26 technical Modules and two non-technical supplementary Modules. In the degree study special emphasis is also given to deepen the theoretical fundamental knowledge in energy and environmental subjects towards engineering applications. The Bachelor thesis completes the degree and is based on a wide spectrum of mathematical/physical and scientific fundamentals.

## Core qualification

The graduates gain a fundamental knowledge of the physical and engineering basics of Mathematics, Physics, Chemistry, Mechanics, Thermodynamics and Materials Science. This enables them to understand phenomena present in Energy Systems, Environmental Engineering and associated disciplines. They understand the fundamental principles of energy and environmental technology for modelling and simulating energy conversion and energy, material and impulse transport processes under consideration of sustainability. They are proficient also in measurement, regulation and control techniques as well as constructive methods.

The graduates are able to:

- formulate and solve technical problems from first principles:
- deepen systematically into processes and methods of their discipline, in order to analyse and evaluate them;
- choose and apply appropriate analysis, modelling, simulation and optimisation methods;
- perform literature surveys and use for their studies databases and other information sources;
- independently plan and perform experiments and interpret the results;
- successfully embark in a Master degree in Energy and Environmental Engineering.

The graduates can perform competently and responsibly various engineering tasks in Energy and Environmental Engineering 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 M0569: Engineering Mechanics I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Engineering Mechanics I (L0187) | Lecture | 3 | 3 |
| Engineering Mechanics I (L0190) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Uwe Weltin |
| **Admission Requirements** | none |
| **Recommended Previous Knowledge** | Elementary knowledge in mathematics and physics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe fundamental connections, theories and methods to calculate forces in statically determined mounted systems of rigid bodies and fundamentals in elastostatics. |
| *Skills* | Students are able to apply theories and methods to calculate forces in statically determined mounted systems of rigid bodies and fundamentals of elastostatics. |
| **Personal Competence** | |
| *Social Competence* | Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities. |
| *Autonomy* | Students are able to solve individually exercises related to this lecture. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min. |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Elective Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Logistics and Mobility: Core qualification: Compulsory<br>Process Engineering: Core qualification: Compulsory |

| Course L0187: Engineering Mechanics I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Course work** | 2 voluntary tests, 30 minutes each with a maximum of four extra points for a final exam with 30 points. The bonus expires after each semester. |
| **Lecturer** | Prof. Uwe Weltin |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Methods to calculate forces in statically determined systems of rigid bodies<br>• Newton-Euler-Method<br>• Energy-Methods<br>Fundamentals of elasticity<br>• Forces and deformations in elastic systems |
| **Literature** | • Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 1: Statik, Springer Vieweg, 2013<br>• Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 2: Elastostatik, Springer Verlag, 2011<br>• Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 1: Statik, Springer Vieweg, 2013<br>• Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 2: Elastostatik, Springer Verlag, 2011<br>• Hibbeler, Russel C.: Technische Mechanik 1 Statik, Pearson Studium, 2012<br>• Hibbeler, Russel C.: Technische Mechanik 2 Festigkeitslehre, Pearson Studium, 2013<br>• Hauger, W.; Mannl, V.; Wall, W.A.; Werner, E.: Aufgaben zu Technische Mechanik 1-3: Statik, Elastostatik, Kinetik, Springer Verlag, 2011 |

| Course L0190: Engineering Mechanics I | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Uwe Weltin |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0577: Nontechnical Complementary Courses for Bachelors

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|---|---|
| **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 |

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| | • to learn to collaborate in different manner,<br>• 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><br>Students are able in selected areas<br><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** |
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| **Information regarding lectures and courses can be found in the corresponding module handbook published separately.** |

## 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 |

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|---|---|
| **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 |
| **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): Core qualification: Compulsory<br>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>Electrical Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: 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>Naval Architecture: Core qualification: Compulsory<br>Process Engineering: 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 |
| **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, 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 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, 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 |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0883: General and Inorganic Chemistry

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals in Inorganic Chemistry (L0824) | Lecture | 4 | 4 |
| Fundamentals in Inorganic Chemistry (L0996) | Laboratory Course | 3 | 2 |

| | |
|---|---|
| **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* | After finalization of the module students are able to describe molecular orbital theory as well as 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, pH calculation, quantitative analysis (titration), redox processes in water, redox potential, Nernst theory describing the concentration dependence of redox potentials, overpotential, corrosion (local elments). |
| *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><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><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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>Process Engineering: Core qualification: Compulsory |

### Course L0824: Fundamentals in Inorganic Chemistry

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|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **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** | Laboratory 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 |

## Module M0957: Introduction into Energy and Environmental Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Energy and Environmental Engineering (L0212) | Problem-based Learning | 4 | 3 |
| Physics-Lab for VT/ BVT/ EUT (L0947) | Laboratory Course | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Alfons Kather |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | None |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can sketch the different options for electricity and heat generation and gain insight into environmental engineering technologies. They are able to present and discuss the technical and environmental engineering advantages and disadvantages (balancing act between affordable energy usage and minimisation of environmental impact) of the different alternatives on a basic level. The students are aware of the dimension of their future responsibility and know about the necessity to find compromises between energy generation and environment protection.<br><br>Through a practical course in physics the students learn to deliver an overview of certain relevant aspects of physics. |
| *Skills* | The students master the fundamentals of technical communication. They are able to explain specialised topics orally. By a comparing analysis of literature sources, students are able to work scientifically and to critically discuss them on a basic level.<br><br>The students are able to communicate their deepened physics knowledge in written technical communication. |
| **Personal Competence** | |
| *Social Competence* | The social skills of the students are strengthened by working in a group as well as visiting a company. For the preparation of the seminar presentation the students gain communication skills.<br><br>The practical course in Physics is also carried out in groups, including the preparation of the test reports. The students strengthen further their social skills, can achieve common results in a group and report those results in joint test protocols. |
| *Autonomy* | In a seminar setting the students learn how to formulate realistically conclusions on their own. The students are able to work independently on specific technical subjects and to present these to the group.<br><br>The students are able to familiarise themselves with experimental demonstrations and individually prepare and present a short experimental report. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Examination** | Presentation |
| **Examination duration and scale** | EEUT: Compulsory attendance and seminar plus 1 p Handout; Physics Lab: error calculation seminar; 6 Experiments with: introd. seminar (20 min), 4 handwritten pages preparatory script, transcript on their own and attestation; 10min short presentation and 1p handout |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory |

| Course L0212: Introduction to Energy and Environmental Engineering | |
|---|---|
| **Typ** | Problem-based Learning |
| **Hrs/wk** | 4 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 34, Study Time in Lecture 56 |
| **Lecturer** | Prof. Alfons Kather |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The course is made up of three components: Lectures by invited speakers, excursions and talks by the students. The lectures by invited speakers are connected to the companies where the excursions take place. From the results of the excursions the students prepare their talks under supervision from faculty staff. The talks are presented to the group and discussed.<br><br>Some example topics are:<br><br>• Conventional steam power plants and combined-cycle power plants<br>• Power plant components (boiler, steam turbine, condenser, feed water heaters, etc.)<br>• Distributed electricity generation and energy supply<br>• District and neighbourhood heating networks<br>• Renewable energy<br>• Energy storage<br>• Electric grids<br>• Energy management at end-user level<br>• Energy-intensive industries<br>• Environmental technology (e.g., wastewater treatment plants) |
| **Literature** | Keine erforderlich |

| Course L0947: Physics-Lab for VT/ BVT/ EUT | |
|---|---|
| **Typ** | Laboratory Course |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Wolfgang Hansen |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | In the physics lab a number of key experiments on physical phenomena in mechanics, oscillatory and wave motion, thermodynamics, electricity, and optics will be conducted by the students under assistance of a lecturing tutor. The experiments are part of the physics education program presented in the course "Physics for TUHH-VT Engineers".<br><br>Beyond teaching of fundamental physical background the objectives are basic skills in preparation and performing physical measurements, usage of physical equipment, analysis of the results and preparation of a report on the experimental data. The students receive instructions in terms of scientific writing as well as feedback on their own reports and level of scientific writing.<br><br>Before every experiment an colloquium takes place in which the students explain and discuss the theoretical background and its translation into practice with the corresponding experiment. |
| **Literature** | Zu den Versuchen gibt es individuelle Versuchsanleitungen, die vor der Versuchsdurchführung ausgegeben werden.<br><br>Zum Teil müssen die zur Versuchsdurchführung notwendigen physikalischen Hintergründe selbstständig erarbeitet werden, wozu die zur Vorlesung "Physik für TUHH-VT Ingenieure" angegebene Literatur gut geeignet ist. |

## Module M0570: Engineering Mechanics II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Engineering Mechanics II (L0191) | Lecture | 3 | 3 |
| Engineering Mechanics II (L0192) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Uwe Weltin |
| **Admission Requirements** | none |
| **Recommended Previous Knowledge** | Technical Mechnics I |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe connections, theories and methods to calculate forces and motions of rigid bodies in 3D. |
| *Skills* | Students are able to apply theories and method to calculate forces and motions of rigid bodies in 3D. |
| **Personal Competence** | |
| *Social Competence* | Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities. |
| *Autonomy* | Students are able to solve individually exercises related to this lecture with instructional direction. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min. |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Elective Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Logistics and Mobility: Core qualification: Compulsory<br>Process Engineering: Core qualification: Compulsory |

### Course L0191: Engineering Mechanics II

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Course work** | 2 voluntary tests, 30 minutes each with a maximum of four extra points for a final exam with 30 points. The bonus expires after each semester. |
| **Lecturer** | Prof. Uwe Weltin |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Method for calculation of forces and motion of rigid bodies in 3D<br>• Newton-Euler-Method<br>• Energy methods |
| **Literature** | • Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 2: Elastostatik, Springer Verlag, 2011<br>• Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 3: Kinetik, Springer Vieweg, 2012<br>• Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 2: Elastostatik, Springer Verlag, 2011<br>• Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 3: Kinetik, Springer Vieweg, 2012<br>• Hibbeler, Russel C.: Technische Mechanik 2 Festigkeitslehre, Pearson Studium, 2013<br>• Hibbeler, Russel C.: Technische Mechanik 3 Dynamik, Pearson Studium, 2012<br>• Hauger, W.; Mannl, V.; Wall, W.A.; Werner, E.: Aufgaben zu Technische Mechanik 1-3: Statik, Elastostatik, Kinetik, Springer Verlag, 2011 |

### Course L0192: Engineering Mechanics II

| | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Uwe Weltin |
| **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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>General Engineering Science (German program, 7 semester): Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Core qualification: Compulsory<br>Logistics and Mobility: Core qualification: 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>Technomathematics: Core qualification: 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. Josef Schlattmann, Prof. Otto von Estorff, 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. Josef Schlattmann, Prof. Otto von Estorff, Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0671: Technical Thermodynamics I

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Gerhard Schmitz |
| **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 1st law of Thermodynamics and are aware about the limits of energy conversions according to 2nd 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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>General Engineering Science (German program, 7 semester): Core qualification: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Core qualification: Compulsory<br>General Engineering Science (English program, 7 semester): Core qualification: Compulsory<br>Computational Science and Engineering: Specialisation Engineering Sciences: 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>Process Engineering: Core qualification: 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. Gerhard Schmitz |
| **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. Gerhard Schmitz |
| **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. Gerhard Schmitz |
| **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) | Laboratory Course | 3 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Patrick Theato |
| **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><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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 Minuten |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: 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. Patrick Theato |
| **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** | Laboratory Course |
| **Hrs/wk** | 3 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 18, Study Time in Lecture 42 |
| **Lecturer** | Prof. Patrick Theato |
| **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 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 |
| **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): Core qualification: Compulsory<br>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>Electrical Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: 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>Naval Architecture: Core qualification: Compulsory<br>Process Engineering: 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 |
| **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, 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 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, 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, Prof. Marko Lindner, Dr. Christian Seifert |
| **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** | NN |
| **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* | none |
| *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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 135 Minuten |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>Logistics and Mobility: Core qualification: Compulsory<br>Mechanical Engineering: Core qualification: Compulsory<br>Naval Architecture: Core qualification: Compulsory<br>Process Engineering: Core qualification: 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** | NN |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | DC networks: Current, voltage, power, Kirchhoff's laws, equivalent sources, 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 |

| 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** | NN |
| **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 M0598: Mechanical Engineering: Design

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Fundamentals of Mechanical Engineering Design<br>• Mechanics<br>• Fundamentals of Materials Science<br>• 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:<br>• explain design guidelines for machinery parts e.g. considering load situation, materials and manufacturing requirements,<br>• describe basics of 3D CAD,<br>• explain basics methods of engineering designing. |
| *Skills* | After passing the module, students are able to:<br>• independently create sketches, technical drawings and documentations e.g. using 3D CAD,<br>• design components based on design guidelines autonomously,<br>• dimension (calculate) used components,<br>• use methods to design and solve engineering design tasks systamtically and solution-oriented,<br>• apply creativity techniques in teams. |
| **Personal Competence** | |
| *Social Competence* | After passing the module, students are able to:<br>• develop and evaluate solutions in groups including making and documenting decisions,<br>• moderate the use of scientific methods,<br>• present and discuss solutions and technical drawings within groups,<br>• reflect the own results in the work groups of the course. |
| *Autonomy* | Students are able<br>• to estimate their level of knowledge using activating methods within the lectures (e.g. with clickers),<br>• To solve engineering design tasks systematically. |
| **Workload in Hours** | Independent Study Time 40, Study Time in Lecture 140 |
| **Credit points** | 6 |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory<br>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 Energy and Enviromental Engineering: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>Mechanical Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Naval Architecture: Core qualification: Compulsory |

| Course L0268: Embodiment Design and 3D-CAD | |
|---|---|
| **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** | Practical Course |
| **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** | Practical Course |
| **Hrs/wk** | 3 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 18, Study Time in Lecture 42 |
| **Lecturer** | Prof. Wolfgang Hintze |
| **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** | 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 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. Gerhard Schmitz |
| **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. |
| *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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>General Engineering Science (German program, 7 semester): Core qualification: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Core qualification: Compulsory<br>General Engineering Science (English program, 7 semester): Core qualification: Compulsory<br>Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory<br>Mechanical Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Technomathematics: Core qualification: Elective Compulsory<br>Technomathematics: Core qualification: 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. Gerhard Schmitz |
| **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. Gerhard Schmitz |
| **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. Gerhard Schmitz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## 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 |
| **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): Core qualification: Compulsory<br>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>Computer Science: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Core qualification: Compulsory<br>General Engineering Science (English program, 7 semester): Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Mechanical Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Naval Architecture: Core qualification: Compulsory<br>Process Engineering: Core qualification: 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 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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Naval Architecture: Compulsory<br>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 Energy and Enviromental Engineering: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>Logistics and Mobility: Specialisation Engineering Science: 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 |

| 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 |

| 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** | Prof. Stefan Müller |
| **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><br>• Bergmann-Schäfer: „Lehrbuch der Experimentalphysik“, Band 2: „Elektromagnetismus“, de Gruyter<br><br>Für die **Atomphysik:**<br><br>• Haken, Wolf: „Atom- und Quantenphysik“, Springer<br><br>Für die **Materialphysik und Elastizität:**<br><br>• Hornbogen, Warlimont: „Metallkunde“, Springer |

## Module M0536: Fundamentals of Fluid Mechanics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Fluid Mechanics (L0091) | Lecture | 2 | 4 |
| 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<br>• Technical Mechanics I+II<br>• Technical Thermodynamics I+II<br>• Working with force balances<br>• Simplification and solving of partial differential equations<br>• Integration |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to:<br>• explain the difference between different types of flow<br>• give an overview for different applications of the Reynolds Transport-Theorem in process engineering<br>• explain simplifications of the Continuity- and Navier-Stokes-Equation by using physical boundary conditions |
| *Skills* | The students are able to<br>• describe and model incompressible flows mathematically<br>• reduce the governing equations of fluid mechanics by simplifications to archive quantitative solutions e.g. by integration<br>• notice the dependency between theory and technical applications<br>• use the learned basics for fluid dynamical applications in fields of process engineering |
| **Personal Competence** | |
| *Social Competence* | The students<br>• are capable to gather information from subject related, professional publications and relate that information to the context of the lecture and<br>• 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)<br>• 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<br>• search further literature for each topic and to expand their knowledge with this literature,<br>• work on their exercises by their own and to evaluate their actual knowledge with the feedback. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Examination** | Written exam |
| **Examination duration and scale** | 3 hours |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Process Engineering: Core qualification: Compulsory |

| Course L0091: Fundamentals of Fluid Mechanics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, 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 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 M0610: Electrical Machines

**Courses**

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

| | |
|---|---|
| **Module Responsible** | NN |
| **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 arw 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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 Minuten |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory<br>Electrical Engineering: Core qualification: Elective Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering: Elective Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory<br>Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory<br>Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory<br>Mechanical Engineering: Core qualification: Elective Compulsory<br>Mechatronics: Core qualification: Compulsory |

| Course L0293: Electrical Machines | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | NN |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Electric field: Coulomb´s law, flux (field) line, work, potential, capacitor, energy, force<br><br>Magnetic field: force, flux line, Ampere´s law, field at bounderies, flux, magnetic circuit, hysteresis, induction, self-induction, mutual inductance, transformer<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 (Squirrelcage vs. sliprings),<br><br>Synchronous machines, construction and layout, equivalent single line diagrams, no-load and short-cuircuit characteristics, vector diagrams, motor and generator operation<br><br>drives with variable speed, inverter fed operation, special drives, step motors, |
| **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 | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | NN |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Exercises to the application of electric and magnetic fields.<br><br>Excercises to the operational performance of eletric machines. |
| **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" |

## Module M0891: Informatics for Process Engineers

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Informatics for Process Engineers (L0836) | Lecture | 2 | 2 |
| Informatics for Process Engineers (L0837) | Recitation Section (small) | 2 | 2 |
| Numeric and Matlab (L0125) | Laboratory Course | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Dr. Marcus Venzke |
| **Admission Requirements** | None. |
| **Recommended Previous Knowledge** | Basic knowledge in using MS Windows. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can describe procedural and object-oriented concepts. |
| *Skills* | Students are capable of object-oriented programming in the programing language Java and of solving mathematic questions by using Matlab.<br>Students are capable of developing concepts (simple algorithms) to solve technical questions. |
| **Personal Competence** | |
| *Social Competence* | Students are able to work out solutions together in small groups. |
| *Autonomy* | - |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Process Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Elective Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Process Engineering: Elective Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Elective Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Elective Compulsory<br>Process Engineering: Core qualification: Compulsory |

| Course L0836: Informatics for Process Engineers | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Marcus Venzke |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Introduction to object-oriented modelling and programming exemplified with Java<br>• Objects, classes<br>• Methods, properties<br>• Inheritance<br>• Basics of the language Java<br>• Sample application: Simulation of an electricity network<br>• 2D graphics<br>• Events and Controls |
| **Literature** | Campione, Mary; Walrath, Kathy: The Java Tutorial - A practical guide for programmers. Addison-Wesley, Reading, Massachusets, 1998.<br>Bibliothek: TII 978<br><br>Krüger, Guido; Hansen, Heiko: Handbuch der Java-Programmierung. 3. Auflage Addison-Wesley, 2002.<br>http://www.javabuch.de/<br><br>Krüger, Guido: Go to Java 2. Addison-Wesley Verlag, Bonn, 1999.<br>Bibliothek: TII 717<br><br>Cowell, John: Essential Java 2 fast. Springer Verlag, London, 1999.<br>Bibliothek: TII 942<br><br>Java SE 7 Documentation<br>http://docs.oracle.com/javase/7/docs/<br><br>Java Platform, Standard Edition 7 API Specification<br>http://docs.oracle.com/javase/7/docs/api/ |

| Course L0837: Informatics for Process Engineers | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Marcus Venzke |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | In the lab, the content from the lecture is practiced and deepened with practical assignments. Every week one or two programming tasks are assigned. These are solved by the students on computers independently, coached by a tutor. |
| **Literature** | Campione, Mary; Walrath, Kathy: The Java Tutorial - A practical guide for programmers. Addison-Wesley, Reading, Massachusets, 1998.<br>Bibliothek: TII 978<br><br>Krüger, Guido; Hansen, Heiko: Handbuch der Java-Programmierung. 3. Auflage Addison-Wesley, 2002.<br>http://www.javabuch.de/<br><br>Krüger, Guido: Go to Java 2. Addison-Wesley Verlag, Bonn, 1999.<br>Bibliothek: TII 717<br><br>Cowell, John: Essential Java 2 fast. Springer Verlag, London, 1999.<br>Bibliothek: TII 942<br><br>Java SE 7 Documentation<br>http://docs.oracle.com/javase/7/docs/<br><br>Java Platform, Standard Edition 7 API Specification<br>http://docs.oracle.com/javase/7/docs/api/ |

| Course L0125: Numeric and Matlab | |
|---|---|
| **Typ** | Laboratory Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Siegfried Rump, Weitere Mitarbeiter |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Programming in Matlab<br>2. Numerical methods for systems of nonlinear equations<br>3. Basics in computer arithmetic<br>4. Linear and nonlinear optimization<br>5. Condition of problems and algorithms<br>6. Verified numerical results with INTLAB |
| **Literature** | **Literatur (Software-Teil):**<br>1. Moler, C., Numerical Computing with MATLAB, SIAM, 2004<br>2. The Math Works, Inc. , MATLAB: The Language of Technical Computing, 2007<br>3. Rump, S. M., INTLAB: Interval Labority, http://www.ti3.tu-harburg.de<br>4. Highham, D. J.; Highham, N. J., MATLAB Guide, SIAM, 2005 |

## Module M0829: Foundations of Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Management (L0880) | Lecture | 3 | 3 |
| Project Entrepreneurship (L0882) | Problem-based Learning | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Christoph Ihl |
| **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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Computer Science: Compulsory<br>General Engineering Science (German program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Civil- and Enviromental Engeneering: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process 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 Computer Science: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental 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 Biomechanics: 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 Materials in Engineering Sciences: 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 Product Development and Production: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>Civil- and Environmental Engineering: Core qualification: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Computer Science: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Civil- and Enviromental Engeneering: Compulsory<br>General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (English program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Civil Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: 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>Naval Architecture: Core qualification: Compulsory<br>Technomathematics: Core qualification: Compulsory<br>Process Engineering: Core qualification: Compulsory |

| 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. Christoph Ihl, Prof. Thorsten Blecker, Prof. Christian Lüthje, Prof. Christian Ringle, Prof. Kathrin Fischer, Prof. Cornelius Herstatt, Prof. Wolfgang Kersten, Prof. Matthias Meyer, Prof. Thomas Wrona |
| **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. |

| Course L0882: Project Entrepreneurship | |
|---|---|
| **Typ** | Problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christoph Ihl, Ann-Isabell Hnida, Hamed Farhadian, Katharina Roedelius, Oliver Welling, Maximilian Muelke |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | In this project module, students work on an Entrepreneurship project. They are required to go through all relevant steps, from the first idea to the concept, using their knowledge from the corresponding lecture.<br><br>Project work is carried out in teams with the support of a mentor. |
| **Literature** | Relevante Literatur aus der korrespondierenden 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 |

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|---|---|
| **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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes; theoretical questions and calculations |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory |

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|---|---|
| | Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Technomathematics: Core qualification: 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 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) | Laboratory 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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes; theoretical questions and calculations |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: 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** | Laboratory Course |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Course work** | Compulsory attendence of the colloquia of all experiments and compulsory report. |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **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 M0639: Gas and Steam Power Plants

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Gas and Steam Power Plants (L0206) | Lecture | 3 | 4 |
| Gas and Steam Power Plants (L0210) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Alfons Kather |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • "Technical Thermodynamics I and II"<br>• "Heat Transfer"<br>• "Fluid Mechanics" |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can evaluate the development of the electricity demand and the energy conversion routes in the thermal power plant, describe the various types of power plant and the layout of the steam generator block. They are also able to determine the operation characteristics of the power plant. Additionally they can describe the exhaust gas cleaning apparatus and the combination possibilities of conventional fossil-fuelled power plants with solar thermal and geothermal power plants or plants equipped with Carbon Capture and Storage.<br><br>The students have basic knowledge about the principles, operation and design of turbomachinery |
| *Skills* | The students will be able, using theories and methods of the energy technology from fossil fuels and based on well-founded knowledge on the function and construction of gas and steam power plants, to identify basic associations in the production of heat and electricity, so as to develop conceptual solutions. Through analysis of the problem and exposure to the inherent interplay between heat and power generation the students are endowed with the capability and methodology to develop realistic optimal concepts for the generation of electricity and the production of heat. From the technical basics the students become the ability to follow better the deliberations on the electricity mix composition within the energy-political triangle (economy, secure supply and environmental protection).<br><br>Within the framework of the exercise the students learn the use of the specialised software suite EBSILON Professional$^{TM}$. With this tool small practical tasks are solved with the PC, to highlight aspects of the design and development of power plant cycles.<br><br>The students are able to do simplified calculations on turbomachinery either as part of a plant, as single component or at stage level. |
| **Personal Competence** | |
| *Social Competence* | An excursion within the framework of the lecture is planned for students that are interested. The students get in this manner direct contact with a modern power plant in this region. The students will obtain first-hand experience with a power plant in operation and gain insights into the conflicts between technical and political issues. |
| *Autonomy* | The students assisted by the tutors will be able to develop alone simple simulation models and run with these scenario analyses. In this manner the theoretical and practical knowledge from the lecture is consolidated and the potential effects from different process combinations and boundary conditions highlighted. The students are able independently to analyse the operational performance of steam power plants and calculate selected quantities and characteristic curves. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Examination** | Written exam |
| **Examination duration and scale** | Written examination of 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Compulsory |

| Course L0206: Gas and Steam Power Plants | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Alfons Kather |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | In the 1st part of the lecture an overview on thermal power plants is offered, including:<br>• Electricity demand and Forecasting<br>• Thermodynamic fundamentals<br>• Energy Conversion in thermal power plants<br>• Types of power plant<br>• Layout of the power plant block<br>• Individual elements of the power plant<br>• Cooling systems<br>• Flue gas cleaning<br>• Operation characteristics of the power plant<br>• Construction materials for power plants<br>• Location of power plants<br>• Solar thermal plants/geothermal plants/Carbon Capture and Storage plants.<br><br>These are complemented in the 2nd part of the module by the more specialised issues:<br>• Energy balance of a turbomachine<br>• Theory of turbine and compressor stage<br>• Equal and positive pressure blading<br>• Flow losses<br>• Characteristic numbers<br>• Axial and radial design<br>• Design features<br>• Hydraulic turbomachines<br>• Pump and water turbine designs<br>• Design examples of reciprocating engines and turbomachinery<br>• Steam power plants<br>• Gas turbine systems. |
| **Literature** | • Kalide: Kraft- und Arbeitsmaschinen<br>• Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985<br>• Strauß, K.: Kraftwerkstechnik. Springer-Verlag, 2006<br>• Kugeler und Phlippen: Energietechnik. Springer-Verlag, 1990<br>• Bohn, T. (Hrsg.): Handbuchreihe Energie, Band 7: Gasturbinenkraftwerke, Kombikraftwerke, Heizkraftwerke und Industriekraftwerke, Technischer Verlag Resch / Verlag TÜV Rheinland |

| Course L0210: Gas and Steam Power Plants | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Alfons Kather |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | In the 1st part of the lecture a general introduction into fluid-flow machines and steam power plants is offered, including:<br>• Energy balance of a fluid-flow machine<br>• Theory of turbine and compressor stage<br>• Equal and positive pressure blading<br>• Flow losses<br>• Characteristic numbers<br>• Axial and radial design<br>• Design features<br>• Hydraulic fluid-flow machines<br>• Pump and water turbine designs<br>• Design examples of reciprocating engines and turbomachinery<br>• Steam power plants<br>• Gas turbine systems<br>• Diesel engine systems<br>• Waste heat utilisation<br>followed by the more specialised issues:<br>• Electricity Demand and Forecasting<br>• Thermodynamic fundamentals<br>• Energy Conversion in Thermal Power Plants<br>• Types of Power Plant<br>• Layout of the power plant block<br>• Individual elements of the power plant<br>• Cooling systems<br>• Flue gas cleaning<br>• Operation characteristics of the power plant<br>• Construction materials<br>• Location of power plants<br>The environmental impact of acidification, fine particulate or $CO_2$ emissions and the resulting climatic effects are a special focus of the lecture and the lecture hall exercise. The challenges in plant operation from interconnecting conventional power plants and renewable energy sources are discussed and the technical options for providing security of supply and network stability are presented, also under consideration of cost effectiveness. In this critical review, focus is especially placed on the compatibility of the different solutions with the environment and climate. With this, the awareness for the responsibility of an engineer's own actions are emphasized and the potential extent of the different solutions presented clearly.<br>Within the framework of the exercise the students learn the use of the specialised software suite EBSILON Professional™. With this tool small tasks are solved on the PC, to highlight aspects of the design and development of power plant cycles. The students present their results orally and can afterwards ask questions and get feedback. The course work has a positive effect on the students final grade. |
| **Literature** | • Skripte<br>• Kalide: Kraft- und Arbeitsmaschinen<br>• Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985<br>• Strauß, K.: Kraftwerkstechnik. Springer-Verlag, 2006<br>• Kugeler und Phlippen: Energietechnik. Springer-Verlag, 1990<br>• T . Bohn (Hrsg.): Handbuchreihe Energie, Band 7: Gasturbinenkraftwerke, Kombikraftwerke, Heizkraftwerke und Industriekraftwerke, Technischer Verlag Resch / Verlag TÜV Rheinland |

## Module M0833: Introduction to Control Systems

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Herbert Werner |
| **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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process 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 Biomechanics: 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 Materials in Engineering Sciences: 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 Product Development and Production: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Computer Science: Specialisation Computational Mathematics: Elective Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Core qualification: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory |

| | |
|---|---|
| | General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Civil Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory<br>Mechanical Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective 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 |

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

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

## Module M0956: Measurement Technology for Mechanical and Process Engineers

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical Course: Measurement and Control Systems (L1119) | Laboratory Course | 2 | 2 |
| Measurement Technology for Mechanical and Process Engineers (L1116) | Lecture | 2 | 3 |
| Measurement Technology for Mechanical and Process Engineers (L1118) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Dr. Sven Krause |
| **Admission Requirements** | none |
| **Recommended Previous Knowledge** | Basic knowledge of physics, chemistry and electrical engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to name the most important fundmentals of the Measurement Technology (Quantities and Units, Uncertainty, Calibration, Static and Dynamic Properties of Sensors and Systems).<br><br>They can outline the most important measuring methods for different kinds of quantities to be maesured (Electrical Quantities, Temperature, mechanical quantities, Flow, Time, Frequency).<br><br>They can describe important methods of chemical Analysis (Gas Sensors, Spectroscopy, Gas Chromatography) |
| *Skills* | Students can select suitable measuring methods to given problems and can use refering measurement devices in practice.<br><br>The students are able to orally explain issues in the subject area of measurement technology and solution approaches as well as place the issues into the right context and application area. |
| **Personal Competence** | |
| *Social Competence* | Students can arrive at work results in groups and document them in a common report. |
| *Autonomy* | Students are able to familiarize themselves with new measurement technologies. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Examination** | Written exam |
| **Examination duration and scale** | 105 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>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 Process Engineering: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory<br>Mechanical Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Process Engineering: Core qualification: Compulsory |

| Course L1119: Practical Course: Measurement and Control Systems | |
|---|---|
| **Typ** | Laboratory Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Wolfgang Schröder |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Experiment 1: Emission and immission measurement of gaseous pollutants: different technologies to determine different gaseous pollutants in automotive exhaust are used.<br><br>Experiment 2: Simulation and measurement of asynchrone engine and rotary pump: the dynamic behaviour of e pump engine will be investigated. The starting will be simulated on a PC and compared with measurement.<br><br>Experiment 3: Michelson interferometer and fiber optic: fundamental optical phenonema will be understood and applications with Michelson interferometer and optical fibers demonstrated.<br><br>Experiment 4:Identification of the parameters of a control system and optimal control parameters |
| **Literature** | Versuch 1:<br><br>• Leith, W.: Die Analyse der Luft und ihrer Verunreinigung in der freien Atmosphäre und am Arbeitsplatz. 2. Aufl., Wissenschaftliche Verlagsgesellschaft, Stuttgart, 1974<br>• Birkle, M.: Meßtechnik für den Immissionsschutz, Messen der gas- und partikelförmigen Luftverunreinigungen. R. Oldenburg Verlag, München-Wien, 1979<br>• Luftbericht 83/84, Freie und Hansestadt Hamburg, Behörde für Bezirksangelegenheiten, Naturschutz und Umweltgestaltung<br>• Gebrauchs- und Bedienungsanweisungen<br>• VDI-Handbuch Reinhaltung der Luft, Band 5: VDI-Richtlinien 2450 Bl.1, 2451 Bl.4, 2453 Bl.5, 2455 Bl.1<br><br>Versuch 2:<br><br>• Grundlagen über elektrische Maschinen, speziell: Asynchronmotoren<br>• Simulationsmethoden, speziell: Verwendung von Blockschaltbildern<br>• Betriebsverhalten von Kreispumpen, speziell: Kennlinien, Ähnlichkeitsgesetze<br><br>Versuch 3:<br><br>• Unger, H.-G.: Optische Nachrichtentechnik, Teil 1: Optische Wellenleiter. Hüthing Verlag, Heidelberg, 1984<br>• Dakin, J., Cushaw, B.: Optical Fibre Sensors: Principles and Components. Artech House Boston, 1988<br>• Culshaw, B., Dakin, J.: Optical Fibre Sensors: Systems and Application. Artech House Boston, 1989<br><br>Versuch 4:<br><br>• Leonhard: Einführung in die Regelungstechnik. Vieweg Verlag, Braunschweig-Wiesbaden<br>• Jan Lunze: Systemtheoretische Grundlagen, Analyse und Entwurf einschleifiger Regelungen |

| Course L1116: Measurement Technology for Mechanical and Process Engineers | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Sven Krause |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 1 Fundamentals<br>1.1 Quantities and Units<br>1.2 Uncertainty<br>1.3 Calibration<br>1.4 Static and Dynamic Properties of Sensors and Systems<br>2 Measurement of Electrical Quantities<br>2.1 Current and Voltage<br>2.2 Impedance<br>2.3 Amplification<br>2.4 Oscilloscope<br>2.5 Analog-to-Digital Conversion<br>2.6 Data Transmission<br>3 Measurement of Nonelectric Quantities<br>3.1 Temperature<br>3.2 Length, Displacement, Angle<br>3.3 Strain, Force, Pressure<br>3.4 Flow<br>3.5 Time, Frequency<br>4 Chemical Analysis<br>4.1 Gas Sensors<br>4.2 Spectroscopy<br>4.3 Gas Chromatography<br>At the end of each lecture students present single measuring techniques and results orally in front of the class. |
| **Literature** | Lerch, R.: „Elektrische Messtechnik; Analoge, digitale und computergestützte Verfahren“, Springer, 2006, ISBN: 978-3-540-34055-3.<br>Profos, P. Pfeifer, T.: „Handbuch der industriellen Messtechnik“, Oldenbourg, 2002, ISBN: 978-3486217940. |

| Course L1118: Measurement Technology for Mechanical and Process Engineers | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Sven Krause |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1275: Environmental Technology

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Dr. Joachim Gerth |
| **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. |
| *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. |
| **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. |
| *Autonomy* | Students can independently exploit sources about of the subject, acquire the particular knowledge and tranfer it to new problems. |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Credit points** | 3 |
| **Examination** | Written exam |
| **Examination duration and scale** | 1 hour written exam |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Process Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Elective Compulsory<br>Bioprocess Engineering: Core qualification: Elective Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Process Engineering: Elective Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Elective Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Elective Compulsory<br>Process Engineering: Core qualification: Elective Compulsory |

### Course L1387: Practical Exercise Environmental Technology

| | |
|---|---|
| **Typ** | Laboratory Course |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Joachim Gerth |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The experiment demonstrates the effect of ionic strength on the binding of dissolved zinc and phosphate by soil surfaces. From the results it can be inferred that the potential of soil surfaces is modified by the application of salt. This has consequences for the retention of nutrients and pollutants. The experiment is carried out with iron oxide rich soil material.<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** | F. Scheffer und P. Schachtschabel (2002): "Lehrbuch der Bodenkunde" TUB Signatur AGG-308<br><br>W.E.H. Blum (2007): "Bodenkunde in Stichworten" TUB Signatur AGG-317<br><br>C. A. J. Appelo; D. Postma (2005): "Geochemistry, groundwater and pollution"<br><br>TUB Signatur GWC-515 |

| Course L0326: Environmental Technologie | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Joachim Gerth, Prof. Martin Kaltschmitt, Prof. Kerstin Kuchta |
| **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 M0618: Renewables and Energy Systems

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Power Industry (L0316) | Lecture | 1 | 1 |
| Energy Systems and Energy Industry (L0315) | Lecture | 2 | 2 |
| Renewable Energy (L0313) | Lecture | 2 | 2 |
| Renewable Energy (L1434) | Recitation Section (small) | 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* | With completion of this module, the students can provide an overview of characteristics of energy systems and their economic efficiency. They can explain the issues occurring in this context. Furthermore, they can explain details of power generation, power distribution and power trading wih regard to subject-related contexts. The students can explain these aspects, which are applicable to many energy systems in general, especially for renewable energy systems and critical discuss them. Furthermore, the students can explain the environmental benefits from the use of such systems. |
| *Skills* | Students are able to apply methodologies for detailed determination of energy demand or energy production for various types of energy systems. Furthermore, they can evaluate energy systems technically, environmentally and economically and design them under certain given conditions. Therefore, they can choose the necessary subject-specific calculation rules, also for not standardized solutions of a problem.<br><br>The students are able to explain questions and possible approaches to its processing from the field of renewable energies orally and to put them them into the right 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. This allows them to make an effective contribuition to a more sustainable power supply. |
| *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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 3 hours written exam |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective 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, Dr. 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 L0315: Energy Systems and Energy Industry | |
|---|---|
| **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** | • Energy: development and significance<br>• Fundamentals and basic concepts<br>• Energy demand and future trends (heat, electricity, fuels)<br>• Energy reserve and sources<br>• Cost and efficiency calculation<br>• Final and effective energy from petroleum, natural gas, coal, uranium and other<br>• Legal, administrative and organizational aspects of energy systems<br>• Energy systems as a permanent optimization task |
| **Literature** | • Kopien der Folien |

| Course L0313: Renewable Energy | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Martin Kaltschmitt |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | • introduction<br>• solar energy for heat and power generation<br>• wind power for electricity generation<br>• hydropower for electricity generation<br>• ocean energy for electricity generation<br>• geothermal energy for heat and electricty generation |
| **Literature** | • Kaltschmitt, M.; Streicher, W.; Wiese, A. (Hrsg.): Erneuerbare Energien - Systemtechnik, Wirtschaftlichkeit, Umweltaspekte; Springer, Berlin, Heidelberg, 2006, 4. Auflage<br>• Kaltschmitt, M.; Streicher, W.; Wiese, A. (Hrsg.): Renewable Energy - Technology, Economics and Environment; Springer, Berlin, Heidelberg,2007 |

| Course L1434: Renewable Energy | |
|---|---|
| **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 |
| **Language** | DE/EN |
| **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>• Deep geothermal energy |
| **Literature** | • Kaltschmitt, M.; Streicher, W.; Wiese, A. (Hrsg.): Erneuerbare Energien - Systemtechnik, Wirtschaftlichkeit, Umweltaspekte; Springer, Berlin, Heidelberg, 2006, 4. Auflage<br>• Kaltschmitt, M.; Streicher, W.; Wiese, A. (Hrsg.): Renewable Energy - Technology, Economics and Environment; Springer, Berlin, Heidelberg,2007 |

## 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) | Laboratory 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 |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: 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** | Laboratory Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Stefan Heinrich |
| **Language** | DE |
| **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 M1274: Environmental Technology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Environmental Assessment (L0860) | Lecture | 2 | 2 |
| Environmental Assessment (L1054) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **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 module the 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* | 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 jointly different solutions and to discuss their theoretical or practical implementation. 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 48, Study Time in Lecture 42 |
| **Credit points** | 3 |
| **Examination** | Written exam |
| **Examination duration and scale** | 1 hour written exam |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Process Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Elective Compulsory<br>Bioprocess Engineering: Core qualification: Elective Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Process Engineering: Elective Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Elective Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Elective Compulsory<br>Process Engineering: Core qualification: Elective Compulsory<br>Process Engineering: Core qualification: Compulsory |

| Course L0860: Environmental Assessment | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Anne Rödl, Dr. Christoph Hagen Balzer |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | **Contaminants:** Impact- and Risk Assessment<br><br>**Environmental damage & precautionary principle:** Environmental Risk Assessment (ERA)<br><br>**Resource and water consumption**: Material flow analysis<br><br>**Energy consumption**: Cumulated energy demand (CED), cost analysis<br><br>**Life cycle concept**: Life cycle assessment (LCA)<br><br>**Sustainability**: Comprehensive product system assessment , SEE-Balance<br><br>**Management**: Environmental and Sustainability management (EMAS)<br><br>**Complex systems**: MCDA and scenario method |
| **Literature** | Foliensätze der Vorlesung<br><br>Studie: **Instrumente zur Nachhaltigkeitsbewertung -** Eine Synopse (Forschungszentrum Jülich GmbH) |

| Course L1054: Environmental 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 |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | **Presentation and application of free software programs in order to understand the concepts of environmental assessment methods better.**<br><br>Within the group exercise 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** | Power point Präsentationen |

# Thesis

## Module M-001: Bachelor Thesis

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Professoren der TUHH |
| **Admission Requirements** | • According to General Regulations §24 (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 |
| **Examination** | according to Subject Specific Regulations |
| **Examination duration and scale** | laut FSPO |
| **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>Computer Science: Thesis: Compulsory<br>Electrical Engineering: Thesis: Compulsory<br>Energy and Environmental Engineering: Thesis: Compulsory<br>General Engineering Science (English program): Thesis: Compulsory<br>General Engineering Science (English program, 7 semester): Thesis: Compulsory<br>Computational Science and Engineering: 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>xx: Thesis: Compulsory<br>Process Engineering: Thesis: Compulsory |