TUHH
Hamburg
University of
Technology

# Module Manual

Bachelor of Science (B.Sc.)

# Chemical and Bioprocess Engineering
# Dual study program

Cohort: Winter Term 2024

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# Program description

## Content

Bio- and chemical engineers utilize the properties of raw materials and develop (bio)catalysts and processes to create new products or to realize more sustainable, energy-saving ways to existing products. In this way, important goals in climate and nature protection can be achieved by making processes more energy-efficient or using carbon dioxide as a substrate for new processes. New products can also include foodstuffs that make it possible to meet the needs of a growing world population while no longer exploiting the planet. Chemical and bioengineers are also helping to develop new medicines and design processes to produce them in large quantities. The basic human needs for clean drinking water, food, energy and health can only be met with the help of chemical engineering and biotechnology. Chemical and bioengineers harness biology, chemistry and physics for society by facilitating the production of food, chemicals, pharmaceuticals, fuels, building materials, metals and plastics on a large scale. Chemical and bioengineering thus bears a great responsibility for a resource-conserving and climate-friendly society. After all, a circular economy with a minimal ecological footprint can only be achieved through efficient material conversion processes with extensive recycling possibilities.

The course teaches the fundamentals of science (chemistry, biology, physics), mathematics, engineering (mechanics, measurement technology, construction) and process technology (thermodynamics, heat and mass transfer). The lecturers of process engineering assume that hybrid processes consisting of biological and chemical sub-processes will become more and more important in the future and therefore biological and chemical basics must be laid for future engineers in the field of process engineering. During the course of studies, students are given the opportunity to gain their first impressions of scientific research on (bio)process engineering systems and apparatus in the laboratory and pilot plant. In addition to the scientific and technical fundamentals, students learn a great deal about the various methods and equipment used to understand and calculate manufacturing processes and (bio)chemical reactions. After learning the basics, students can then choose a specialization topic in the fourth semester and specialize in chemical engineering or bioengineering.

The bioengineering specialization focuses on the areas of technical microbiology, biocatalysis and bioprocess engineering and teaches concepts and methods of biochemistry, genetics and micro-, molecular- and cell biology. The goal is to make understandable how biocatalysts and scalable biotechnological processes can be designed in order to design new sustainable biotechnological processes. The chemical engineering specialization enables students to recognize and formulate laws that can be used to plan, calculate, design, build and operate apparatus, machines and entire production plants for environmentally compatible processes.

Independent of the chosen specialization, the following master's degree programs can be chosen at the TUHH after a bachelor's degree in chemical and bioengineering can be chosen:

→ Process Engineering

→ Bioprocess Engineering

→ Chemical and Bioprocess Engineering

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

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

## Career prospects

In principle, the following fields of activity are open to all graduates of process engineering courses:

Fields of activity in industry:

- Development and improvement of chemical, biotechnical or environmental processes
- Project planning, plant construction and operation of corresponding plants
- Elaboration of basic principles and development of new apparatus and processes
- Materials research and development
- Management in production plants
- Occupational safety and safety engineering
- Documentation and patent processing
- Marketing and sales

Fields of activity in the public sector:

- Research and teaching at scientific universities or institutes
- Technical administration and supervision
- Work in federal and state offices, e.g. patent office, trade supervisory office, materials testing office, Federal Environmental Agency

Freelance perspectives:

- Engineering offices
- Patent law firms
- Expert witnesses, industrial consultants
- Own company foundation

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

## Learning target

**Learning objectives Knowledge**

Graduates will be able to reproduce basic knowledge in the fields of mathematics, physics, biology, chemistry and mechanics.

- They will be able to explain the phenomena occurring in chemical and bioengineering and related disciplines.
- They will be able to explain the basic principles of chemical and bioengineering for the design, modeling and simulation of biological and process engineering processes and chemical reactions, of energy, mass and momentum transport processes, of separation processes on the micro, meso and macro scales, and for the operation of corresponding plants.

- They are able to describe the basic features of measurement, control and regulation technology.
- They are able to consider legal aspects in connection with (bio)process engineering processes and production plants.

Chemical engineering specialization:

- Graduates of the chemical engineering specialization are able to understand fundamental interrelationships in chemical processes and to implement these using additional knowledge of materials technology and plant and apparatus engineering, particularly with a focus on the use of renewable raw materials to realize production processes that are as sustainable as possible.
- Furthermore, graduates will be able to describe possible uses of renewable energies for the design of energy-efficient and climate-friendly production processes.

Bioengineering specialization:

- Graduates of the Bioengineering specialization are able to apply basic molecular biology techniques to specifically modify microorganisms for the production of chemicals and proteins.
- They will also be able to explain and apply the microbial, energetic, and process fundamentals of fermentative bioprocesses.
- They will be able to explain different kinetic approaches to growth and product formation of various microorganisms and apply them to bioprocess development and quantify transport processes in the bioreactor and use them to scale-up bioprocesses.

**Learning objectives Skills**

- Graduates will be able to apply their knowledge of mathematical and scientific principles and methods of engineering to simple problems and develop solutions.
- They can map typical, detailed problems from chemical and bioengineering (e.g. design of plants, calculation of heat and mass transfer processes) to their basic knowledge, find suitable solution methods and implement them. They are able to document the chosen solution method appropriately in writing.
- They can map practical, rather general problems from chemical and bioengineering (e.g. design of a process) to subproblems of their own subject or other relevant subjects, find suitable methods for solving the problem and implement them. They can present their solution to an audience in a clearly structured manner.
- They can work independently on given research problems using appropriate methods, document their chosen solution and present it to a knowledgeable audience.
- They are able to develop designs for (bio)process engineering processes according to specified requirements.
- They are able to independently plan and conduct experiments and interpret the results.

Chemical engineering specialization:

- Graduates of the chemical engineering specialization are able to understand, analyze and evaluate chemical mass transfer processes in technical gases and liquids from the molecular scale to the apparatus scale.
- They can develop designs for chemical processes according to specified requirements; select and apply appropriate analysis, modeling, and optimization methods; apply techniques and methods of chemical engineering; and assess their limitations.

Bioengineering major:

- Graduates of the Bioengineering specialization are able to penetrate, analyze and evaluate biological material conversion processes with biocatalysts (cells and enzymes) at the molecular and process level.
- They are able to develop designs for bioprocesses according to specified requirements; select and apply appropriate analysis, modeling, and optimization methods; apply bioprocess engineering techniques and methods and assess their limitations.

**Learning objectives Social competence**

- Graduates are qualified to cooperate with experts from other disciplines and to present the results of their work comprehensibly in written and oral form.
- They are able to communicate about contents and problems of chemical and bioengineering with experts and laymen in German and English.
- They can respond appropriately to inquiries, additions and comments. You can work independently both individually and in (international) groups.
- They can define, distribute and integrate subtasks. They can make time arrangements and interact socially.

**Learning objectives Independence**

- Graduates have the ability to responsibly apply their knowledge in different areas, taking into account safety, ecological and economic requirements, and to deepen their knowledge on their own responsibility.
- They have the ability to conduct literature research and to use databases and other sources of information for their work.
- They can realistically assess their existing competencies and work through deficits independently. They are able to assess the non-technical implications of engineering work.
- They are able to organize and carry out projects.

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

## Program structure

The study program is structured as follows:

- core qualification,
- specialization and
- Bachelor's thesis.

The core qualification comprises 180 CP including all five practice modules with a total of 30 CP. All modules of the core qualification have to be completed by all students. The core qualification also comprises the module "Linking Theory and practice (dual study program, Bachelor's degree)".

From the fourth semester onwards the students attend modules of their chosen specialization. Possible specializations are Chemical Engineering and Bioengineering. The specialization comprises 15 CP. Two modules (each 6 CP) are mandatory, one module (3 CP) can be chosen from a selection of modules.

The Bachelor's thesis is located in the sixth semester and is generally done within the student's company.

In total, the dual study program Chemical and Bioengineering comprises 210 CP with a standard period of study of six semesters. Therefore, it is a program of intensive study.

## Core Qualification

### Module M0883: General and Inorganic Chemistry

**Courses**

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

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

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

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

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

## Module M0850: Mathematics I

**Courses**

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

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

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

| Course L2971: Mathematics I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sabine Le Borne, Dr. Christian Seifert, Dr. Jens-Peter Zemke |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L2972: Mathematics I | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sabine Le Borne, Dr. Christian Seifert, Dr. Jens-Peter Zemke |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1760: Introduction to Chemical and Bioengineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Chemical and Bioengineering (L2892) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Johannes Gescher |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | No previous experience is required. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After successfully completing this module, students will be able to:<br>- give an overview of the most important topics in chemical and bioengineering.<br>- to explain some working methods for different subfields of chemical engineering.<br>- to conduct scientific literature research independently<br>- to formulate simple scientific texts and to cite them correctly |
| *Skills* | After successfully completing this module, students will be able to:<br>- use publication databases independently<br>- to cite correctly<br>- to describe typical process engineering and biotechnological processes independently and roughly with the help of references. |
| **Personal Competence** | |
| *Social Competence* | Students will be able to:<br>- compile work results in groups and document them<br>- give appropriate feedback and deal constructively with feedback on their own performance |
| *Autonomy* | Students will be able to independently assess their learning and reflect on their weaknesses and strengths in the field of chemical engineering and biochemical engineering. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / 20 % / Written elaboration / Die Studierenden schreiben in Gruppen kurze Übersichtsartikel zu den Themen der Veranstaltung unter Anwendung der vermittelten Regeln für die Literaturrecherche und -zitation. |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory |

### Course L2892: Introduction to Chemical and Bioengineering

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des SD V |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The course pursues three important goals for the education of chemical and bioengineers. Using examples such as the production of penicillin or the Haber-Bosch process, the lecturers of process engineering present how green engineering processes can be developed with the help of process engineering approaches and methods and which development stages are passed through in the process. The lecturers also show how such processes can be made increasingly sustainable with the help of new research directions and results. In addition, students learn the basis of scientific literature research and how this can be used to open up a new subject area. They also learn how to distinguish between scientific and non-scientific sources. Finally, the students create their own short scientific texts and learn how to cite correctly and safely. |
| **Literature** | Literatur und zusätzliche Informationsquellen werden während der Veranstaltung über StudIP zur Verfügung gestellt. |

## Module M1761: Biological and Biochemical Fundamentals

**Courses**

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

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

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

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

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

## Module M1802: Engineering Mechanics I (Stereostatics)

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Benedikt Kriegesmann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Solid school knowledge in mathematics and physics. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can<br>• describe the axiomatic procedure used in mechanical contexts;<br>• explain important steps in model design;<br>• present technical knowledge in stereostatics. |
| *Skills* | The students can<br>• explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems;<br>• apply basic statical methods to engineering problems;<br>• estimate the reach and boundaries of statical methods and extend them to be applicable to wider problem sets. |
| **Personal Competence** | |
| *Social Competence* | The students can work in groups and support each other to overcome difficulties. |
| *Autonomy* | Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Data Science: Specialisation II. Application: Elective Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

### Course L1001: Engineering Mechanics I (Statics)

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Benedikt Kriegesmann |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Tasks in Mechanics<br>• Modelling and model elements<br>• Vector calculus for forces and torques<br>• Forces and equilibrium in space<br>• Constraints and reactions, characterization of constraint systems<br>• Planar and spatial truss structures<br>• Internal forces and moments for beams and frames<br>• Center of mass, volumn, area and line<br>• Computation of center of mass by intergals, joint bodies<br>• Friction (sliding and sticking)<br>• Friction of ropes |
| **Literature** | K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009).<br>D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1. 11. Auflage, Springer (2011). |

| Course L1003: Engineering Mechanics I (Statics) | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Benedikt Kriegesmann |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Forces and equilibrium<br>Constraints and reactions<br>Frames<br>Center of mass<br>Friction<br>Internal forces and moments for beams |
| **Literature** | K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009).<br>D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1. 11. Auflage, Springer (2011). |

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

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

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

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

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

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

**Courses**

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

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

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

## Module M0888: Organic Chemistry

**Courses**

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

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

### Course L0831: Organic Chemistry

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

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

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

## Module M0671: Technical Thermodynamics I

**Courses**

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

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

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

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

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

## Module M0851: Mathematics II

**Courses**

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

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

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

| Course L2977: Mathematics II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sabine Le Borne, Dr. Christian Seifert, Dr. Jens-Peter Zemke, Prof. Marko Lindner |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L2978: Mathematics II | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sabine Le Borne, Dr. Christian Seifert, Dr. Jens-Peter Zemke, Prof. Marko Lindner |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1276: Fundamentals of Technical Drawing

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Technical Drawing (L1741) | Lecture | 1 | 1 |
| Fundamentals of Technical Drawing (L1742) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Dr. Marko Hoffmann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Basic internship |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students will learn how to generate technical drawing/create technical drawings according to norms<br>• Students will become acquainted with the various types of views in drawings (procection methods, views, sectional representations)<br>• Students will learn how to insert the dimensions in technical drawings<br>• Students will acquire the skills to render data in detailed drawings according to norms (e.g. tolerance dimensioning, fits and surface specifications) |
| *Skills* | • Students are capable to construct simple technical drawings, considering tolerances and fits.<br>• Students are capable to strengthen the spatial sense. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to work together in basic groups on subject related tasks and small design studies and present their results. |
| *Autonomy* | • They work on their homework by their own and get feedback in their particular basis group to evaluate their actual knowledge.<br>• Students are capable to self-reliantly gather information from subject related, professional publications and relate that information to the context of the lecture, e.g. preparing of technical drawings or choosing of a construction material for a process equipment. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | Compulsory: No; Bonus: 5 %; Form: Excercises; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core Qualification: Elective Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

### Course L1741: Fundamentals of Technical Drawing

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Marko Hoffmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Technical drawing basics (contents, kinds of drawings and generation of drawings according to relevant standards)<br>• Projective geometry (basics, orthographic projections, isometric projections, cuts, developed views, penetration views) |
| **Literature** | • Hoischen, Hans; Fritz, Andreas (Hrsg.): "Hoischen/Technisches Zeichnen: Grundlagen, Normen, Beispiele, Darstellende Geometrie", 35. überarbeitete und aktualisierte Auflage, Cornelsen Verlag, Berlin, 2016.<br>• Fritz, Andreas; Hoischen, Hans; Rund, Wolfgang (Hrsg.): "Praxis des Technischen Zeichnens Metall / Erklärungen, Übungen, Tests", 17. überarbeitete Auflage; Cornelsen Verlag, Berlin, 2016.<br>• Labisch, Susanna; Weber, Christian: "Technisches Zeichnen : Selbstständig lernen und effektiv üben", 4. überarbeitete und erweiterte Auflage, Springer Vieweg Verlag, Wiesbaden, 2013.<br>• Kurz, Ulrich; Wittel, Herbert: "Böttcher/Forberg Technisches Zeichnen : Grundlagen, Normung, Übungen und Projektaufgaben", 26. überarbeitete und erweiterte Auflage, Springer Vieweg Verlag, Wiesbaden, 2014.<br>• Klein, Martin; Alex, Dieter u.a.; DIN: Deutsches Institut für Normung e.V. (Hrsg.): "Einführung in die DIN-Normen"; 14. neubearbeitete Auflage, Teubner u.a., Stuttgart u.a., 2008. |

| Course L1742: Fundamentals of Technical Drawing | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Dr. Marko Hoffmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1803: Engineering Mechanics II (Elastostatics)

**Courses**

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

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

### Course L0494: Engineering Mechanics II (Group Exercise)

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

| Course L1691: Engineering Mechanics II (Plenary Exercise) | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Cyron, Martin Legeland |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The lecture Engineering Mechanics II introduces the fundamental concepts of stress and strain and explains how these can be used to characterize and compute elastic deformations of mechanical bodies under loading. The focus of the lecture lies on:<br>• basis of continuum mechanics: stress, strain, constitutive laws<br>• truss<br>• torsion bar<br>• beam theory: bending, moment of inertia of area, transverse shear<br>• energy methods: Maxwell-Betti reciprocal work theorem, Castigliano's second theorem, theorem of Menabrea<br>• strength of materials: maximum principle stress criterion, yield criteria according to Tresca and von Mises<br>• stability of mechanical structures: Euler buckling strut |
| **Literature** | • Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 1, Springer<br>• Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 2 Elastostatik, Springer |

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

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

**Courses**

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

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

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

## Module M0892: Chemical Reaction Engineering

**Courses**

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

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

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

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

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

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

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

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

## Module M0688: Technical Thermodynamics II

**Courses**

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

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

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

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

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

## Module M0853: Mathematics III

**Courses**

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

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

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

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

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

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

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

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

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

**Courses**

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

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

**Course achievement**

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

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

### Course L2270: Practical Course Measurement Technology

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

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

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

## Module M1764: Bioprocess Technology I

**Courses**

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

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

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

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

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

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

**Courses**

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

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

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

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

**Courses**

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

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

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

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

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

## Module M0544: Phase Equilibria Thermodynamics

**Courses**

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

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

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

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

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

## Module M0536: Fundamentals of Fluid Mechanics

**Courses**

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

**Module Responsible**
Prof. Michael Schlüter

**Admission Requirements**
None

**Recommended Previous Knowledge**

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

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

**Professional Competence**

*Knowledge*
Students are able to:

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

*Skills*
The students are able to

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

**Personal Competence**

*Social Competence*
The students

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

*Autonomy*
The students are able to

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

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

**Credit points**
6

**Course achievement**

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

**Examination**
Written exam

**Examination duration and scale**
3 hours

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

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

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

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

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

**Courses**

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

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

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

## Module M0546: Thermal Separation Processes

**Courses**

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

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

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

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

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

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

## Module M0538: Heat and Mass Transfer

**Courses**

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

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

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

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

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

## Module M0833: Introduction to Control Systems

**Courses**

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

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

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

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

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

**Courses**

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

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

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

## Module M1775: Economic and environmental project assessment

**Courses**

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

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

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

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

### Course L0860: Basics of Environmental Project Assessment

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

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

## Module M0670: Particle Technology and Solids Process Engineering

**Courses**

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

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

### Course L0434: Particle Technology I

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

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

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

## Module M1969: Conceptual Process Design

**Courses**

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

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

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

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

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

## Specialization Bio Engineering

### Module M0877: Fundamentals in Molecular Biology

**Courses**

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

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

#### Course L0889: Genetics and Molecular Biology

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

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

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

## Module M1765: Bioprocess Technology II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Bioprocess Technology II (L2896) | Lecture | 2 | 4 |
| Bioprocess Technology II (L2897) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Anna-Lena Heins |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Content of module "Biological and biochemical fundamentals"<br>• Content of module "Bioprocess Technology I"<br>• Content of module “Fundamentals in Molecular Biology” |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After successful completion of this module, students should be able<br>• explain the microbial, energetic and engineering principles of biotechnological production processes,<br>• assess substance transport effects in heterogeneous processes with immobilized enzymes and cells<br>• classify and apply approaches to mathematical modeling of biotechnological processes<br>• explain the essential features of typical bioreactors and select suitable bioreactors for different biotechnological production processes,<br>• understand and quantify transport phenomena in bioreactors and consider them for bioprocess scale-up<br>• explain and design typical downstream processes for bio-processes,<br>• identify specific scientific problems and solutions for different types of fermentation processes<br>• classify the legal framework for handling biological materials. |
| *Skills* | After successful completion of this module, students should be able to<br>• to identify scientific questions or possible practical problems for concrete industrial applications (e.g. cultivation of microorganisms and animal cells) and to formulate solutions,<br>• evaluate heterogeneous processes with immobilized enzymes and cells with regard to mass transport effects<br>• to assess the application of scale-up criteria for different types of bioreactors and processes and to apply these criteria to given problems (e.g. microbial and cell culture processes),<br>• to formulate questions for the analysis and optimization of real biotechnological production processes and appropriate solutions. |
| **Personal Competence** | |
| *Social Competence* | After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork. |
| *Autonomy* | After completion of this module participants are able to acquire new sources of knowledge and apply their knowledge to previously unknown issues and to present these. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Compulsory |

| Course L2896: Bioprocess Technology II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anna-Lena Heins, Prof. Andreas Liese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction: state-of-the-art and development trends of microbial and biocatalytic bioprocesses, introduction to the lecture<br>• Medium design and optimization, sterilization<br>• mathematical description of material transport effects in heterogeneous reactions with immobilized enzymes, microorganisms or cells<br>• Basic concepts for mathematical models for bio-processes<br>• Bioreactors - concepts, design, control, operation, scale-up<br>• Downstream processing in biotechnological production processes<br>• Selected biotechnological production processes (e.g. antibiotics, amino acids, therapeutic antibodies)<br>• Repititorium |
| **Literature** | P. F. Stanbury, A. Whitaker, S. J. Hall, Principles of Fermentation Technology, 3 rd. Edition, Butterworth-Heinemann, 2016.<br>H. Chmiel, R. Takors, D. Weuster-Botz (Herausgeber): Bioprozeßtechnik, Springer Spektrum, 2018<br>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010<br>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997<br>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013<br>V.C. Hass, R. Pörtner: Praxis der Bioprozesstechnik, Springer Spektrum, 2011 |

| Course L2897: Bioprocess Technology II | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anna-Lena Heins, Prof. Andreas Liese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction: state-of-the-art and development trends of microbial and biocatalytic bioprocesses, introduction to the lecture<br>• Medium design and optimization, sterilization<br>• Mass transport effects for immobilised enzymes, microorganisms and cells<br>• Bioreactors - design, scale-up<br>• Downstream processing in biotechnological production processes<br>• Selected biotechnological production processes (e.g. antibiotics, amino acids, therapeutic antibodies)<br>The students present exercises and discuss them with their fellow students and faculty. |
| **Literature** | P. F. Stanbury, A. Whitaker, S. J. Hall, Principles of Fermentation Technology, 3 rd. Edition, Butterworth-Heinemann, 2016.<br>H. Chmiel, R. Takors, D. Weuster-Botz (Herausgeber): Bioprozeßtechnik, Springer Spektrum, 2018<br>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010<br>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997<br>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013<br>V.C. Hass, R. Pörtner: Praxis der Bioprozesstechnik, Springer Spektrum, 2011 |

## Module M1766: Advanced Practical Course in Bioengineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Advanced Practical Course in Bioengineering (L2898) | Practical Course | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Andreas Liese |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Content of module "Biological and biochemical fundamentals"<br>• Content of module “Fundamentals in Molecular Biology”<br>• Content of module "Bioprocess Technology I"<br>• Content of module “Bioprocess Technology II” |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After successful completion of this module, students know<br>• the relevant strategies for the design and scale-up of a production plant for a microbial processes (up-stream),<br>• the relevant features of typical bioreactors for selection of suitable bioreactors for different biotechnological production processes,<br>• process strategies for fermentation processes,<br>• tools for the optimization of process strategies,<br>• the peculiarities and solution approaches for different biotechnological production processes. |
| *Skills* | After successful completion of this module, students should be able to<br>• explain and apply the relevant strategies for the design and scale-up of a production plant for a microbial processes (up-stream),<br>• explain the relevant features of typical bioreactors and select suitable bioreactors for different biotechnological production processes,<br>• explain and select process strategies for fermentation processes,<br>• apply tools for the optimization of process strategies,<br>• to understand and describe the peculiarities and solution approaches for different biotechnological production processes. |
| **Personal Competence** | |
| *Social Competence* | After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork. |
| *Autonomy* | After completion of this module participants are able to acquire new sources of knowledge and apply their knowledge to previously unknown issues and to present these. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Presentation and colloqium |
| **Assignment for the Following Curricula** | Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Compulsory |

### Course L2898: Advanced Practical Course in Bioengineering

| | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Andreas Liese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | In groups, the students plan a production plant for a microbial process (up-stream) using the "Bioprocess Trainer" software from Hass & Pörtner "Praxis der Bioprozesstechnik". The design of the production plant should combine two major topics: plant technology (bioreactors, type, power input, gassing, stirrer, scale-up, etc.) and processes strategy (process modes, feeding strategies, etc.).<br><br>The results are presented in presentations on the current status of the work and a final presentation and summarized in a written elaboration. |
| **Literature** | V.C. Hass, R. Pörtner: Praxis der Bioprozesstechnik, Springer Spektrum, 2011<br><br>H. Chmiel, R. Takors, D. Weuster-Botz (Herausgeber): Bioprozesstechnik, Springer Spektrum, 2018 |

## Module M1762: Material Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Material Engineering (L2894) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Dr. Marko Hoffmann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • General and Inorganic Chemistry<br>• Phase Equilibria Thermodynamics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | A basic knowledge of materials science is necessary for the design of process plants and apparatus with the associated piping. This module therefore focuses on ferrous materials, although polymer materials and ceramics are also covered. A basic understanding of atomic structure, microstructure, phase transformation, diffusion, state diagrams, and alloy formation, among other things, is necessary for materials selection and for the evaluation of corrosion and wear processes, which students should acquire in this one-semester module. Students will also have basic knowledge in the area of mechanical properties of materials including the essential methods of materials testing and the corrosion processes that are very relevant in practice. In addition, students gain knowledge of the main types of steel used in process engineering and knowledge of the most important heat treatment processes of steels in practice in the context of time-temperature transformation diagrams (TTT diagrams). |
| *Skills* | Students will be able to select suitable materials for the design of process plants and apparatus. Mechanical properties such as strength, ductility, toughness and fatigue strength are taken into account. Students can also specify measures to increase corrosion resistance. In addition to specifying strength-increasing measures, students may select other measures to modify mechanical properties, such as heat treatment processes. |
| **Personal Competence** | |
| *Social Competence* | The students are able to work out results in groups and document them, provide appropriate feedback and handle feedback on their own performance constructively. |
| *Autonomy* | Students are able to independently assess their level of learning and reflect on their weaknesses and strengths in the field of materials engineering. Students are also able to independently seek out information from subject-specific publications and relate this to the context of the course, e.g. when selecting a material for a process engineering apparatus. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory |

| Course L2894: Material Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Marko Hoffmann |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction<br>• Atomic structure and bonding<br>• Structure of solids<br>• Miller indices<br>• Imperfections in solids<br>• Texture<br>• Diffusion<br>• Mechanical properties<br>• Dislocations and strengthening mechanisms<br>• Phase transformations<br>• Phase diagrams, iron-carbon phase diagram<br>• Metallic materials<br>• Corrosion<br>• Polymeric materials<br>• Ceramic materials |
| **Literature** | • Bargel, H.-J.; Schulze, G. (Hrsg.): Werkstoffkunde. Berlin u.a., Springer Vieweg, 2012.<br>• Bergmann, W.: Werkstofftechnik 1. München u.a., Hanser, 2009.<br>• Bergmann, W.: Werkstofftechnik 2. München u.a., Hanser, 2008.<br>• Callister, W. D.; Rethwisch, D. G.: Materialwissenschaften und Werkstofftechnik: eine Einführung, Übersetzungshrsg.: Scheffler, M., 1. Auflage, Weinheim, Wiley-VCH, 2013.<br>• Seidel, W. W.,Hahn, F.: Werkstofftechnik. München u.a., Hanser, 2012. |

## Module M1498: Practice of Process Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practice in Process Engineering (L2271) | Project Seminar | 2 | 2 |
| Lectures for Pratice of Process Engineering (L2272) | Seminar | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Irina Smirnova |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After passing this module the students have the ability to:<br>• give an overview of a certain important field on process and bioprocess engineering,<br>• explain some working methods for different fields in process engineering. |
| *Skills* | After successfully completing this module, students are able to<br>• prepare a written summary of a process engineering topic<br>• to briefly present and discuss a topic in a short presentation<br>• to roughly describe independently typical process engineering and biotechnological processes by means of notes. |
| **Personal Competence** | |
| *Social Competence* | The students are able to<br>• work out results in groups and document them,<br>• provide appropriate feedback and handle feedback on their own performance constructively. |
| *Autonomy* | The students are able to estimate their progress of learning by themselves and to deliberate their lack of knowledge in Process Engineering and Bioprocess Engineering. |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | 1 DIN A4 page report to be handed out to the person responsible for the module + presentation at the end of the semester |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core Qualification: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Process Engineering: Core Qualification: Compulsory |

### Course L2271: Practice in Process Engineering

| | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des SD V |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | The following activities can be credited to students:<br>• Internships in industry (e.g. also during the semester break)<br>• Completed practical projects with construction and workshop activities (basic internship) at institutes of the faculty<br>• Activities on experimental plants at institutes of the faculty<br>• Own project in the student workshop<br>• Small projects in the FabLab |
| **Literature** | |

| Course L2272: Lectures for Pratice of Process Engineering | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dozenten des SD V |
| **Language** | DE/EN |
| **Cycle** | WiSe/SoSe |
| **Content** | The following events can be credited as lectures:<br>• Ring-Lectures<br>• VT Colloquia<br>• Presentations of Master Thesises<br>For further information please visit https://www.tuhh.de/verfahrenstechnik/lehre.html |
| **Literature** | |

## Module M1769: Regulatory aspects of biological agents

**Courses**

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

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

### Course L2865: Regulatory aspects of biological agents

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

## Module M1770: Bioinformatics

**Courses**

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

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

### Course L2899: Bioinformatics

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

## Module M0829: Foundations of Management

**Courses**

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

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

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

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

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

## Specialization Chemical Engineering

### Module M1715: Renewable Energies

**Courses**

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

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

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

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

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

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

## Module M0729: Construction and Apparatus Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Construction and Apparatus Engineering (L0617) | Lecture | 2 | 3 |
| Construction and Apparatus Engineering (L0619) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Dr. Marko Hoffmann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Fundamentals of Technical Drawing<br>• Engineering Mechanics I (Stereostatics)<br>• Engineering Mechanics II (Elastostatics)<br>• Measurement Technology for Chemical and Bioprocess Engineerin<br>• Basic internship |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can reproduce an overview of the important basic materials in engineering applications with priority on apparatus and plant engineering.<br>• Students can reproduce fundamentals of design, strength of material calculation and material selection for elements of process equipment.<br>• Students can reproduce basic principles of connecting and combining elements of apparatuses.<br>• Students have basic knowledge in the following areas: haft-hub connections, bearings, screwed connections, welded connections and sealings |
| *Skills* | • Students are capable to read and interpret complex technical drawings.<br>• Students are capable to calculate wall thickness of simple elements.<br>• Students are capable to design bolted flange connections.<br>• Students are capable to roughly design shell-and-tube heat exchangers. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to work together in basic groups on subject related tasks and small design studies and present their results. |
| *Autonomy* | • Students are capable to self-reliantly gather information from subject related, professional publications and relate that information to the context of the lecture, e.g. preparing of technical drawings or choosing of a construction material for a process equipment.<br>• They work on their homework by their own and get feedback in their particular basis group to evaluate their actual knowledge. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: No; Bonus: 5 %; Form: Excercises; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0617: Construction and Apparatus Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Marko Hoffmann |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction and terminology<br>• Basic materials for process engineering<br>• Examples of apparatuses and their elements<br>• Construction conforming to standards of technical drawings and flow diagram<br>• Perspective illustration of pipe systems and apparatus elements<br>• Boiler formula<br>• Stresses and strains of thick-walled cylindrical shells<br>• Wall thickness calculations of thin-walled cylindrical shells applying mechanical strength criterion and equivalent stresses<br>• System flange-bolt-gasket, sealings<br>• Shaft-hub connections<br>• Bearings<br>• Screwed connections<br>• Welded connections<br>• Heat exchangers |
| **Literature** | • Bargel, H.-J.; Schulze, G. (Hrsg.): Werkstoffkunde. Berlin u.a., Springer Vieweg, 2012.<br>• Bergmann, W.: Werkstofftechnik 1. München u.a., Hanser, 2009.<br>• Bergmann, W.: Werkstofftechnik 2. München u.a., Hanser, 2008.<br>• Callister, W. D.; Rethwisch, D. G.: Materialwissenschaften und Werkstofftechnik: eine Einführung, Übersetzungshrsg.: Scheffler, M., 1. Auflage, Weinheim, Wiley-VCH, 2013.<br>• Klapp, E.: Apparate- und Anlagentechnik, Springer, Berlin, 2002.<br>• Tietze, W.: Taschenbuch Dichtungstechnik, Vulkan, Essen, 2005.<br>• Titze, H., Wilke, H.-P.: Elemente des Apparatebaus, Springer, Berlin, 1992.<br>• Schwaigerer, S., Mühlenbeck, G.: Festigkeitsberechnung im Dampfkessel-, Behälter- und Rohrleitungsbau, Springer, Berlin, 1997.<br>• Seidel, W. W.,Hahn, F.: Werkstofftechnik. München u.a., Hanser, 2012.<br>• Wagner, W.: Festigkeitsberechnungen im Apparate- und Rohrleitungsbau, Würzburg, Vogel, 2007.<br>• Wittel, H., Muhs, D., Jannasch, D.; Voßiek, J.: Roloff/Matek Maschinenelemente, Wiesbaden, Springer Vieweg, 22. Auflage, 2015. |

| Course L0619: Construction and Apparatus Engineering | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Marko Hoffmann |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction and terminology<br>• Basic materials for process engineering<br>• Examples of apparatuses and their elements<br>• Construction conforming to standards of technical drawings and flow diagram<br>• Perspective illustration of pipe systems and apparatus elements<br>• Boiler formula<br>• Stresses and strains of thick-walled cylindrical shells<br>• Wall thickness calculations of thin-walled cylindrical shells applying mechanical strength criterion and equivalent stresses<br>• System flange-bolt-gasket, sealings<br>• Shaft-hub connections<br>• Bearings<br>• Screwed connections<br>• Welded connections<br>• Heat exchangers |
| **Literature** | • Bargel, H.-J.; Schulze, G. (Hrsg.): Werkstoffkunde. Berlin u.a., Springer Vieweg, 2012.<br>• Bergmann, W.: Werkstofftechnik 1. München u.a., Hanser, 2009.<br>• Bergmann, W.: Werkstofftechnik 2. München u.a., Hanser, 2008.<br>• Callister, W. D.; Rethwisch, D. G.: Materialwissenschaften und Werkstofftechnik: eine Einführung, Übersetzungshrsg.: Scheffler, M., 1. Auflage, Weinheim, Wiley-VCH, 2013.<br>• Klapp, E.: Apparate- und Anlagentechnik, Springer, Berlin, 2002.<br>• Tietze, W.: Taschenbuch Dichtungstechnik, Vulkan, Essen, 2005.<br>• Titze, H., Wilke, H.-P.: Elemente des Apparatebaus, Springer, Berlin, 1992.<br>• Schwaigerer, S., Mühlenbeck, G.: Festigkeitsberechnung im Dampfkessel-, Behälter- und Rohrleitungsbau, Springer, Berlin, 1997.<br>• Seidel, W. W.,Hahn, F.: Werkstofftechnik. München u.a., Hanser, 2012.<br>• Wagner, W.: Festigkeitsberechnungen im Apparate- und Rohrleitungsbau, Würzburg, Vogel, 2007.<br>• Wittel, H., Muhs, D., Jannasch, D.; Voßiek, J.: Roloff/Matek Maschinenelemente, Wiesbaden, Springer Vieweg, 22. Auflage, 2015. |

## Module M1762: Material Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Material Engineering (L2894) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Dr. Marko Hoffmann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • General and Inorganic Chemistry<br>• Phase Equilibria Thermodynamics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | A basic knowledge of materials science is necessary for the design of process plants and apparatus with the associated piping. This module therefore focuses on ferrous materials, although polymer materials and ceramics are also covered. A basic understanding of atomic structure, microstructure, phase transformation, diffusion, state diagrams, and alloy formation, among other things, is necessary for materials selection and for the evaluation of corrosion and wear processes, which students should acquire in this one-semester module. Students will also have basic knowledge in the area of mechanical properties of materials including the essential methods of materials testing and the corrosion processes that are very relevant in practice. In addition, students gain knowledge of the main types of steel used in process engineering and knowledge of the most important heat treatment processes of steels in practice in the context of time-temperature transformation diagrams (TTT diagrams). |
| *Skills* | Students will be able to select suitable materials for the design of process plants and apparatus. Mechanical properties such as strength, ductility, toughness and fatigue strength are taken into account. Students can also specify measures to increase corrosion resistance. In addition to specifying strength-increasing measures, students may select other measures to modify mechanical properties, such as heat treatment processes. |
| **Personal Competence** | |
| *Social Competence* | The students are able to work out results in groups and document them, provide appropriate feedback and handle feedback on their own performance constructively. |
| *Autonomy* | Students are able to independently assess their level of learning and reflect on their weaknesses and strengths in the field of materials engineering. Students are also able to independently seek out information from subject-specific publications and relate this to the context of the course, e.g. when selecting a material for a process engineering apparatus. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory |

| Course L2894: Material Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Marko Hoffmann |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction<br>• Atomic structure and bonding<br>• Structure of solids<br>• Miller indices<br>• Imperfections in solids<br>• Texture<br>• Diffusion<br>• Mechanical properties<br>• Dislocations and strengthening mechanisms<br>• Phase transformations<br>• Phase diagrams, iron-carbon phase diagram<br>• Metallic materials<br>• Corrosion<br>• Polymeric materials<br>• Ceramic materials |
| **Literature** | • Bargel, H.-J.; Schulze, G. (Hrsg.): Werkstoffkunde. Berlin u.a., Springer Vieweg, 2012.<br>• Bergmann, W.: Werkstofftechnik 1. München u.a., Hanser, 2009.<br>• Bergmann, W.: Werkstofftechnik 2. München u.a., Hanser, 2008.<br>• Callister, W. D.; Rethwisch, D. G.: Materialwissenschaften und Werkstofftechnik: eine Einführung, Übersetzungshrsg.: Scheffler, M., 1. Auflage, Weinheim, Wiley-VCH, 2013.<br>• Seidel, W. W.,Hahn, F.: Werkstofftechnik. München u.a., Hanser, 2012. |

## Module M1498: Practice of Process Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practice in Process Engineering (L2271) | Project Seminar | 2 | 2 |
| Lectures for Pratice of Process Engineering (L2272) | Seminar | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Irina Smirnova |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After passing this module the students have the ability to:<br>• give an overview of a certain important field on process and bioprocess engineering,<br>• explain some working methods for different fields in process engineering. |
| *Skills* | After successfully completing this module, students are able to<br>• prepare a written summary of a process engineering topic<br>• to briefly present and discuss a topic in a short presentation<br>• to roughly describe independently typical process engineering and biotechnological processes by means of notes. |
| **Personal Competence** | |
| *Social Competence* | The students are able to<br>• work out results in groups and document them,<br>• provide appropriate feedback and handle feedback on their own performance constructively. |
| *Autonomy* | The students are able to estimate their progress of learning by themselves and to deliberate their lack of knowledge in Process Engineering and Bioprocess Engineering. |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | 1 DIN A4 page report to be handed out to the person responsible for the module + presentation at the end of the semester |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core Qualification: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory<br>Process Engineering: Core Qualification: Compulsory |

### Course L2271: Practice in Process Engineering

| | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des SD V |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | The following activities can be credited to students:<br>• Internships in industry (e.g. also during the semester break)<br>• Completed practical projects with construction and workshop activities (basic internship) at institutes of the faculty<br>• Activities on experimental plants at institutes of the faculty<br>• Own project in the student workshop<br>• Small projects in the FabLab |
| **Literature** | |

| Course L2272: Lectures for Pratice of Process Engineering | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dozenten des SD V |
| **Language** | DE/EN |
| **Cycle** | WiSe/SoSe |
| **Content** | The following events can be credited as lectures:<br>• Ring-Lectures<br>• VT Colloquia<br>• Presentations of Master Thesises<br>For further information please visit https://www.tuhh.de/verfahrenstechnik/lehre.html |
| **Literature** | |

## Module M1768: Fundamentals of Chemical Kinetics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Chemical Kinetics (L2895) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Raimund Horn |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • formulation and balancing of chemical reaction equations<br>• basic knowledge of stoichiometry<br>• basic knowledge of chemical thermodynamics, in particular chemical equilibrium<br>• basic knowledge of measurement technology (temperature, pressure, measurement of concentrations)<br>• basic knowledge of chemical reaction engineering (plug flow reactor, batch reactor, continuously stirred tank reactor)<br>• formulation and solution of ordinary differential equations (analytical (partial fractions, integrating factor), numerical (solver, stiffness etc.)) |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | students<br>• can explain basic concepts of chemical kinetics (rate of a chemical reaction, rate of change of species mole numbers, reversible and irreversible reactions, reaction orders, rate constant, activation energy, elementary step, reaction coordinate, reaction mechanism, rate determining step, Arrhenius equation, etc,)<br>• know about experimental methods to measure the kinetics of chemical reactions on various time scales and can explain how they work<br>• can recognize and sketch concentration time profiles of parallel-, consecutive- and equilibrium reactions<br>• know about the differential and integral method of kinetic analysis and the method of half-life times<br>• know the mathematical shape of rate laws of heterogeneously catalyzed reactions<br>• know about reactions that oscillate in time and space and can explain the origin of these oscillations |
| *Skills* | students<br>• can formulate and integrate differential rate laws of chemical reactions either analytically or numerically<br>• can integrate sink- and source terms of chemical species in models of chemical reactors and couple them with the kinetics of the reactions<br>• can plan and perform kinetic measurements<br>• can analyze measured kinetic data and determine kinetic parameters (reaction orders, pre-exponential factors, activation energies)<br>• formulate reaction networks and simplify them with tools like sensitivity analysis and reaction path analysis<br>• formulate reaction mechanisms of heterogeneously catalyzed reactions and derive rate laws according to the formalism of Langmuir Hinshelwood Huge Watson |
| **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 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min |
| **Assignment for the Following Curricula** | Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Chemical and Bioprocess Engineering, Focus Chemical Engineering: Compulsory |

| Course L2895: Fundamentals of Chemical Kinetics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Raimund Horn |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Basic terminology, concepts and definitions in Chemical Kinetics (reaction rate, rate of species consumption or production, reaction rate constant, reaction order, activation energy, reversible and irreversible reactions, homogeneous and heterogeneous reactions, elementary steps, molecularity, reaction coordinate, reaction mechanism, quasi steady state principle, Bodenstein principle)<br><br>Measurement of kinetic data in the laboratory on time scales from days to femtoseconds (classic reactor experiments, stopped-flow method, flash-photolysis, shock tube experiments, relaxation methods, femtochemistry, molecular beams, pump-probe experiments)<br><br>Kinetics of simple reactions (0. Order, 1. Order, 2. Order, 3. Order, differential and integrated rate laws, integration of rate laws by the method of partial fractions), half-life times, radiocarbon dating, differential kinetic analysis, integral kinetic analysis, isolation method, method of initial reaction rates, parameter estimation in kinetic models by linear and non-linear fitting of rate laws to experimental data<br><br>Kinetics of complex reactions (parallel reactions, reversible reactions, consecutive reactions, consecutive reactions with preceding equilibrium), impact of kinetics on product selectivity and yield, integration of the occurring inhomogeneous ODE's by means of the method of the integrating factor<br><br>Numerical integration of kinetic differential equations, stiffness, accuracy, stability, difference and convergence behavior of explicit and implicit solvers, mathematical formulation of complex kinetic reaction networks, numerical implementation in Matlab, Lotka-Volterra model, usage of implicit and explicit solvers in Matlab.<br><br>Examples and handling of complex reaction networks, radical chain reactions (non-branched and branched), sensitivity analysis, reduction of complex reaction networks and integration of reactor simulations, reaction path analysis, eigenvalue analysis of kinetic systems, stable and unstable solutions, chemical oscillations, Belousov-Zhabotinskii Reaction (mathematical analysis, chemical mechanism, origin of oscillations, experimental demonstration).<br><br>Kinetics of heterogeneous catalytic reactions, Langmuir-Hinshelwood-Hougen-Watson rate laws, simplification of LHHW rate laws, reaction orders and apparent activation energies in heterogeneous catalysis.<br><br>Theory of chemical reactions and theoretical calculation of rate constants, kinetic theory of gases, Maxwell-Boltzmann distribution of speeds and energy, collision frequencies, simple collision theory, modified collision theory, Transition State Theory, partition functions, Eyring equation. |
| **Literature** | 1. Chemical Kinetics and Catalysis, R. I. Masel, Wiley Interscience<br>2. Chemical Kinetics and Reaction Dynamics, P. L. Houston, Dover<br>3. Chemical Kinetics, K. J. Laidler, Harper & Row<br>4. Reaction Kinetics, M. J. Pilling, P. W. Seakins, Oxford Science Publications<br>5. Kinetics and Mechanism, J. W. Moore, R. G. Pearson, John Wiley & Sons<br>6. Chemical Kinetics and Dynamics, J. I. Steinfeld, J. S. Francisco, W. L. Hase, Prentice Hall<br>7. Chemically Reacting Flow, R. J. Kee, M. E. Coltrin, P. Glarborg, Wiley Interscience<br>8. The Foundation of Chemical Kinetics, S. W. Benson, Kriger Publishing Company |

## Module M0829: Foundations of Management

**Courses**

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

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

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

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

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

# Thesis

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

**Courses**

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

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