TUHH
Hamburg
University of
Technology

Module Manual

Bachelor of Science (B.Sc.)

Chemical and Bioprocess Engineering

Cohort: Winter Term 2022

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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

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

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.

Program structure

The curriculum of the bachelor's program is structured as a Y-model. It has a common core qualification (150 LP) and the two specializations Chemical Engineering and Bioengineering (18 LP each), one of which has to be chosen in the fourth semester. The specializations consist of compulsory modules of 15 LP and an elective module of 3 LP. The final thesis comprises 12 LP, so that the total scope for the bachelor's degree program is 180 LP.

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	Sstudents are able to handle molecular orbital theory including the octahedral ligand field, qualitatively describe the resulting electron density distribution and structures of molecules (VSEPR); they have developed an idea of molecular interactions in the gas, liquid and solid phases. They are able to describe chemical reactions in the sense of retention of mass and energy, enthalpy and entropy as well as the chemical equilibrium. They can explain the concept of activation energy in conjucture with particle kinetic energy. They have increased knowledge of acid-base concepts, acid-base reactions in water, can perform pH calculations, understand titration as a quantitative analysis. They can recognize redox processes, correlate redox potentials to Gibbs energy, handle Nernst theory in describing the concentration dependence of redox potentials, known the concept of overpotential and understand corrosion as a redox reaction (local element).
Skills	Students are able to use general and inorganic chemistry for the design of technical processes. Especially they are able to formulate mass and energy balances and by this to optimise technical processes. They are able to perform simple calculations of pH values in regard to an application of acids and bases, and evaluate the course of redox processes (calculation of redoxpotentials). They are able to transform a verbal formulated message into an abstract formal procedure. Students are able to present and discuss their scientific results in plenum. The students are able to document the results of their experiments scientifically. They are able to use scientific citation methods in their reports.
Personal Competence	
Social Competence	The students are able to discuss given tasks in small groups and to develop an approach. 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. 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** / **Bonus** / **Form** / **Description** Yes / None / Subject theoretical and practical work /
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory

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

Course L0996: Fundamentals in Inorganic Chemistry	
Typ	Practical Course
Hrs/wk	3
CP	2
Workload in Hours	Independent Study Time 18, Study Time in Lecture 42
Lecturer	Prof. Gerrit A. Luinstra
Language	DE
Cycle	WiSe
Content	This laboratory course comprises the following four topics, i) atomic structure and application of spectroscopic methods, introduction of analytic methods ii) chemical reactions (qualitative analysis), bonding types, reaction types, reaction equations iii) acid-base concepts, acid-base reactions in water, buffer solution, quantitative analysis (titration) iv), redox processes in water, redox potential, Nernst theory describing the concentration dependence of redox potentials, galvanic elements and electrolysis. 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 Chemie, Charles Mortimer (Deutsch und Englisch verfügbar) Analytische und anorganische Chemie, Jander/Blasius Maßanalyse, Jander/Jahr

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

Module M0577: Non-technical Courses for Bachelors

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

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

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

Module M0850: Mathematics I

Courses

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

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	School mathematics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in analysis and linear algebra. They are able to explain them using appropriate examples. • Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples. • 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. • Students are able to discover and verify further logical connections between the concepts studied in the course. • 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. • 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. • 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 Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

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

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

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

Module 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: - give an overview of the most important topics in chemical and bioengineering. - to explain some working methods for different subfields of chemical engineering. - to conduct scientific literature research independently - to formulate simple scientific texts and to cite them correctly
Skills	After successfully completing this module, students will be able to: - use publication databases independently - to cite correctly - 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: - compile work results in groups and document them - 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	None
Examination	Written elaboration
Examination duration and scale	max. 5 pages
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory Chemical and Bioprocess Engineering: Core Qualification: 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. At the end of the module - you will be able to describe basic principles of living systems and explain the metabolism of organisms by applying them. - you will be able to assign organisms to the three kingdoms of life based on some basic characteristics - you will be able to describe the tasks of enzymes generically on the basis of some example reactions - you will be able to deduce from the basic characteristics of organisms and enzymes which biotechnological applications are possible with these systems. - you can understand and use the technical vocabulary of biological systems and processes - you will be able to perform simple bioinformatic operations to assign DNA sequences to a function - 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, - to gather knowledge in groups of about 2 to 10 students - to introduce their own knowledge and to argue their view in discussions in teams - 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 Chemical and Bioprocess Engineering: Core Qualification: 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 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	3
Engineering Mechanics I (Statics) (L1003)	Recitation Section (large)	1	1
Engineering Mechanics I (Statics) (L1002)	Recitation Section (small)	2	2

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

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

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

Module M0888: Organic Chemistry

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

Module Responsible	Prof. Ralph Holl
Admission Requirements	None
Recommended Previous Knowledge	High School Chemistry and/or lecture "general and inorganic chemistry"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are familiar with basic concepts of organic chemistry. They are able to classify organic molecules and to identify functional groups and to describe the respective synthesis routes. Fundamental reaction mechanisms like nucleophilic substitution, eliminations, additions and aromatic substitution can be described. Students are capable to describe in general modern reaction mechanisms.
Skills	Students are able to use basics of organic chemistry for the design of technical processes. Especially they are able to formulate basic routes to synthesize small organic molecules and by this to optimise technical processes in Process Engineering. They are able to transform a verbally formulated message into an abstract formal procedure. The students are able to document and interpret their working process and results scientifically.
Personal Competence	
Social Competence	The students are able to discuss in small groups and develop an approach for given tasks.
Autonomy	Students are able to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
Workload in Hours	Independent Study Time 82, Study Time in Lecture 98
Credit points	6
Course achievement	**Compulsory** Yes · **Bonus** None · **Form** Subject theoretical and practical work · **Description**
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory

Course L0831: Organic Chemistry

Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Nina Schützenmeister
Language	DE
Cycle	SoSe
Content	The lecture covers basic concepts of organic chemistry. This includes simple carbon compounds, alkanes, alkenes, aromatic compounds, alcohols, phenols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, amides and amino acids. Further, fundamentals of reaction mechanisms will be described. This includes nucleophilic substitution, eliminations, additions and aromatic substitution. Also modern reaction mechanisms will be described.
Literature	gängige einführende Werke zur Organischen Chemie. Z.B. „Organische Chemie“ von K.P.C.Vollhart & N.E.Schore, Wiley VCH

Course L0832: Organic Chemistry	
Typ	Practical Course
Hrs/wk	3
CP	2
Workload in Hours	Independent Study Time 18, Study Time in Lecture 42
Lecturer	Prof. Nina Schützenmeister
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. 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. The students write up a report for every experiment. They receive feedback to their level of scientific writing (citation methods, labeling of graphs, etc.), so that they can improve their competence in this field over the course of the practical course.
Literature	gängige einführende Werke zur Organischen Chemie. Z.B. „Organische Chemie“ von K.P.C.Vollhart & N.E.Schore, Wiley VCH

Module M0671: Technical Thermodynamics I

Courses

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

Module Responsible	Prof. Arne Speerforck
Admission Requirements	None
Recommended Previous Knowledge	Elementary knowledge in Mathematics and Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are familiar with the laws of Thermodynamics. They know the relation of the kinds of energy according to 1 st law of Thermodynamics and are aware about the limits of energy conversions according to 2nd law of Thermodynamics. They are able to distinguish between state variables and process variables and know the meaning of different state variables like temperature, enthalpy, entropy and also the meaning of exergy and anergy. They are able to draw the Carnot cycle in a Thermodynamics related diagram. They know the physical difference between an ideal and a real gas and are able to use the related equations of state. They know the meaning of a fundamental state of equation and know the basics of two phase Thermodynamics.
Skills	Students are able to calculate the internal energy, the enthalpy, the kinetic and the potential energy as well as work and heat for simple change of states and to use this calculations for the Carnot cycle. They are able to calculate state variables for an ideal and for a real gas from measured thermal state variables.
Personal Competence	
Social Competence	The students 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 Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory

Course 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 2. Fundamental terms 3. Thermal Equilibrium and temperature 3.1 Thermal equation of state 4. First law 4.1 Heat and work 4.2 First law for closed systems 4.3 First law for open systems 4.4 Examples 5. Equations of state and changes of state 5.1 Changes of state 5.2 Cycle processes 6. Second law 6.1 Carnot process 6.2 Entropy 6.3 Examples 6.4 Exergy 7. Thermodynamic properties of pure fluids 7.1 Fundamental equations of Thermodynamics 7.2 Thermodynamic potentials 7.3 Calorific state variables for arbitrary fluids 7.4 state equations (van der Waals u.a.)
Literature	• Schmitz, G.: Technische Thermodynamik, TuTech Verlag, Hamburg, 2009 • Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Auflage, Springer Verlag, Berlin 2012 • 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. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	Mathematics I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name further concepts in analysis and linear algebra. They are able to explain them using appropriate examples. • Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples. • 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. • Students are able to discover and verify further logical connections between the concepts studied in the course. • 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. • 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. • 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 Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

Course L2976: Mathematics II	
Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Anusch Taraz
Language	DE
Cycle	SoSe
Content	
Literature	

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

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

Module 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 • Students will become acquainted with the various types of views in drawings (procection methods, views, sectional representations) • Students will learn how to insert the dimensions in technical drawings • 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. • 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. • 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 Chemical and Bioprocess Engineering: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory 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) • 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. • Fritz, Andreas; Hoischen, Hans; Rund, Wolfgang (Hrsg.): "Praxis des Technischen Zeichnens Metall / Erklärungen, Übungen, Tests", 17. überarbeitete Auflage; Cornelsen Verlag, Berlin, 2016. • Labisch, Susanna; Weber, Christian: "Technisches Zeichnen : Selbstständig lernen und effektiv üben", 4. überarbeitete und erweiterte Auflage, Springer Vieweg Verlag, Wiesbaden, 2013. • Kurz, Ulrich; Wittel, Herbert: "Böttcher/Forberg Technisches Zeichnen : Grundlagen, Normung, Übungen und Projektaufgaben", 26. überarbeitete und erweiterte Auflage, Springer Vieweg Verlag, Wiesbaden, 2014. • 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 (Elastostatics) (L0493)	Lecture	2	2
Engineering Mechanics II (Elastostatics) (L1691)	Recitation Section (large)	2	2
Engineering Mechanics II (Elastostatics) (L0494)	Recitation Section (small)	2	2

Module Responsible	Prof. Christian Cyron
Admission Requirements	None
Recommended Previous Knowledge	Engineering Mechanics I, Mathematics I (basic knowledge of rigid body mechanics such as balance of linear and angular momentum, basic knowledge of linear algebra like vector-matrix calculus, basic knowledge of analysis such as differential and integral calculus)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Having accomplished this module, the students know and understand the basic concepts of continuum mechanics and elastostatics, in particular stress, strain, constitutive laws, stretching, bending, torsion, failure analysis, energy methods and stability of structures.
Skills	Having accomplished this module, the students are able to - apply the fundamental concepts of mathematical and mechanical modeling and analysis to problems of their choice - apply the basic methods of elastostatics to problems of engineering, in particular in the design of mechanical structures - 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 Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

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

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

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

Module 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 Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory 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 7. Gas - vapor - mixtures 10. Open sytems with constant flow rates 11. Combustion processes 12. Special fields of Thermodynamics
Literature	• Schmitz, G.: Technische Thermodynamik, TuTech Verlag, Hamburg, 2009 • Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Auflage, Springer Verlag, Berlin 2012 • 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 M0892: Chemical Reaction Engineering

Courses

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

Module Responsible	Prof. Raimund Horn
Admission Requirements	None
Recommended Previous Knowledge	Contents of the previous modules mathematics I-III, physical chemistry, technical thermodynamics I+II as well as computational methods for engineers.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to explain basic concepts of chemical reaction engineering. They are able to point out differences between thermodynamical and kinetical processes. The students have a strong ability to outline parts of isothermal and non-isothermal ideal reactors and to describe their properties.
Skills	After successful completion of the module, students are able to: - apply different computational methods to dimension isothermal and non-isothermal ideal reactors, - determine and compute stable operation points for these reactors , - 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**: Yes; **Bonus**: None; **Form**: Subject theoretical and practical work; **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 Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory 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) 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) 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) 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) 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) 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) 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 skript Frerich Keil Books: M. Baerns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, Technische Chemie, Wiley-VCH G. Emig, E. Klemm, Technische Chemie, Springer A. Behr, D. W. Agar, J. Jörissen, Einführung in die Technische Chemie E. Müller-Erlwein, Chemische Reaktionstechnik 2012, 2. Auflage, Teubner Verlag J. Hagen, Chemiereaktoren: Auslegung und Simulation, 2004, Wiley-VCH H. S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall B H. S. Fogler, Essentials of Chemical Reaction Engineering, Prentice Hall O. Levenspiel, Chemical Reaction Engineering, John Wiley & Sons, 1998 L. D. Schmidt, The Engineering of Chemical Reactions, Oxford Univ. Press, 2009 J. B. Butt, Reaction Kinetics and Reactor Design, 2000, Marcel Dekker R. Aris, Elementary Chemical Reactor Analysis, Dover Pubn. Inc., 2000 M. E. Davis, R. J. Davis, Fundamentals of Chemical Reaction Engineering, McGraw Hill G. F. Froment, K. B. Bischoff, J. De Wilde, Chemical Reactor Analysis and Design, John Wiley & Sons, 2010 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) 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) 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) 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) 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) 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) 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 skript Frerich Keil Books: M. Baerns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, Technische Chemie, Wiley-VCH G. Emig, E. Klemm, Technische Chemie, Springer A. Behr, D. W. Agar, J. Jörissen, Einführung in die Technische Chemie E. Müller-Erlwein, Chemische Reaktionstechnik 2012, 2. Auflage, Teubner Verlag J. Hagen, Chemiereaktoren: Auslegung und Simulation, 2004, Wiley-VCH H. S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall B H. S. Fogler, Essentials of Chemical Reaction Engineering, Prentice Hall O. Levenspiel, Chemical Reaction Engineering, John Wiley & Sons, 1998 L. D. Schmidt, The Engineering of Chemical Reactions, Oxford Univ. Press, 2009 J. B. Butt, Reaction Kinetics and Reactor Design, 2000, Marcel Dekker R. Aris, Elementary Chemical Reactor Analysis, Dover Pubn. Inc., 2000 M. E. Davis, R. J. Davis, Fundamentals of Chemical Reaction Engineering, McGraw Hill G. F. Froment, K. B. Bischoff, J. De Wilde, Chemical Reactor Analysis and Design, John Wiley & Sons, 2010 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: * Batch reactor - Estimation of kinetic parameters for the saponification of ethylacetate *CSTR - Residence time distribution, reaction *CSTR in Series - Residence time distribution, reaction * Plug Flow Reactor - Residence time distribution, reaction 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. 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) Praktikumsskript Skript Chemische Verfahrenstechnik 1 (F.Keil)

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. • Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples. • 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. • Students are able to discover and verify further logical connections between the concepts studied in the course. • 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. • 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. • 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 Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Logistics and Mobility: Specialisation Information Technology: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Naval Architecture: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Compulsory

Course L1028: Analysis III	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	WiSe
Content	Main features of differential and integrational calculus of several variables • Differential calculus for several variables • Mean value theorems and Taylor's theorem • Maximum and minimum values • Implicit functions • Minimization under equality constraints • Newton's method for multiple variables • Fourier series • Double integrals over general regions • Line and surface integrals • 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 • Introduction and elementary methods • Exsitence and uniqueness of initial value problems • Linear differential equations • Stability and qualitative behaviour of the solution • Boundary value problems and basic concepts of calculus of variations • Eigenvalue problems • Numerical methods for the integration of initial and boundary value problems • 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. 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. Practical course: Pressure drop in piping, calorimetry, image data acquisition, flow measurement, concentration measurement and mass transfer, capacitive measurements of solid concentrations, spectroscopy, error calculation, chromatography
Skills	Literature research, categorisation of thematical topics, analysis of an experimental test stand, preparation of test protocol, first programming with Matlab, use of relevant laboratory measurement technology, preparation of a test protocol, execution of calculations.
Personal Competence	
Social Competence	Arrangement and division of work in practical training and learning groups, assessment of own level of knowledge, work on the experimental stand in groups, consultation with persons responsible for teaching, presentation of the preparation of the experiment, tolerance of frustration
Autonomy	Time management of the workload, independent development of the thematic basics, personal responsibility for the provision of protective equipment and work clothing, practice of presentation in front of a group, active participation in the lectures, formulation of enquiries/detailed questions by using clicker.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	**Compulsory**: No; **Bonus**: 20 %; **Form**: Excercises; **Description**: Popup-Quizzes wählen der Vorlesung
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory 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. Kamke, W.: Der Umgang mit experimentellen Daten, insbesondere Fehleranalyse, im physikalischen Anfänger-Praktikum. Eine elementare Einführung. W. Kamke, Kirchzarten [Keltenring 197], 2010. 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. 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. Strohrmann, Günther (2004): Messtechnik im Chemiebetrieb. Einführung in das Messen verfahrenstechnischer Größen. 10., durchges. Aufl. München: Oldenbourg. 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. 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. Mechanics of gases and fluids - hydrostatics and hydrodynamics Thermodynamics - temperature, heat, heat transport, ideal gas, changes of state, cyclic processes, laws of thermodynamics 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 D. Meschede (Hrsg.): Gerthsen Physik, Springer-Verlag Jay Orear: Physik, Hanser Verlag 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" • 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: • to describe basic processes of bioprocess engineering, • to assign different types of kinetics to enzymes and microorganisms and to distinguish inhibition types, • to name and describe the parameters of stoichiometry and rheology, • to explain the mass transport processes in bioreactors fundamentally, • to understand and describe the basics of bioprocess management (batch and continuously operated reactor types, calculation of the batch reaction time,...) in great detail, • 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 • using various kinetic approaches, to determine substrate turnover by enzymes as well as their kinetic parameters, • describe the growth of whole cells with the help of different kinetic approaches as well as to determine their kinetic parameters, • qualitatively predict the effects of enzyme inhibition on the behavior of enzymes and on the overall process, • analyze and determine bioprocesses based on the stoichiometry of the reaction system, • differentiate the various basic reactor types in biotechnological processes and select them specifically for the respective application, • set up and solve mass balance and differential equations for the mathematical description of fermentation processes, • 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	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 Chemical and Bioprocess Engineering: Core Qualification: 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 • Immobilisation of enzymes and whole cells • Stoichiometry of cell growth and product formation • Microbial growth kinetics and growth models • Maintenance metabolism • Basic bioprocess reactor types • Batch, fed-batch, chemostate and turbidostate fermentation • Calculation of main parameters of fermentative processes • Rheology and mechanical energy input • Gassing of bioprocesses (aerobic and microaerobic) • Discussion with bioprocess engineers of large and small companies, proportionally alumni of TUHH • Repetitorium
Literature	A. Liese, K. Seelbach, C. Wandrey: Industrial Biotransformations, Wiley-VCH,2nd ed. 2006 H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997 P. M. Doran: Bioprocess Engineering Principles, 2nd. edition, Academic Press, 2013 H. Chmiel, R. Takors, D. Weuster-Botz (Herausgeber): Bioprozeßtechnik, Springer Spektrum, 2018 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. The students document their experiments and results in a protocol.
Literature	Skript

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	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** No; **Bonus** 10 %; **Form** Attestation; **Description** Testate finden semesterbegleitend statt.
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory Logistics and Mobility: Specialisation Information Technology: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory Mechatronics: Specialisation Medical Engineering: Compulsory Mechatronics: Specialisation Dynamic Systems and AI: Compulsory Mechatronics: Specialisation Electrical Systems: Elective Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Compulsory

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

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Sibylle Fröschle
Language	DE
Cycle	SoSe
Content	
Literature	John V. Guttag: Introduction to Computation and Programming Using Python. 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. • They learn how state variables are influenced by the mixing of compounds and learn concepts to quantitatively describe these properties. • 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. • 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. • 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. • For specific applications, they are able to self-reliantly find necessary physico-chemical properties of compounds as well as model parameters in literature sources. • Beside pure compound properties the students are capable of describing the properties of mixtures. • The students know how to visualize phase equilibria graphically and they know how to interpret the occurring phenomena. • 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. • 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 General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory 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 2. Thermodynamic equations in multi-component systems: Fundamental equations, chemical potential, fugacity 3. Phase equilibria of pure substances: thermodynamic equilibrium, vapor pressure, Gibbs’ phase rule 4. Equations of state: virial equations, van-der-Waals equation, generalized equations of state 5. Mixing properties: ideal and real mixtures, excess properties, partial molar properties 6. Vapor-liquid-equilibria: binary systems, azeotropes, equilibrium condition 7. Gas-liquid-equilibria: equilibrium condition, Henry-coefficient 8. G^E-Models: Hildebrand-model, Flory-Huggins-model, Wilson-model, UNIQUAC, UNIFAC 9. Liquid-liquid-equilibria: equilibrium condition, phase equilibria in binary and ternary systems 10. Solid-liquid-equilibria: equilibrium condition, binary systems 11. Chemical reactions: reaction coordinate, mass action law, influence of pressure and temperature 12. Osmotic pressure
Literature	• Jürgen Gmehling, Bärbel Kolbe: Thermodynamik. VCH 1992 • J.M. Prausnitz, R.N. Lichtenthaler, E.G. de Azevedo: Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed. Prentice Hall, 1999. • 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 2. Thermodynamic equations in multi-component systems: Fundamental equations, chemical potential, fugacity 3. Phase equilibria of pure substances: thermodynamic equilibrium, vapor pressure, Gibbs’ phase rule 4. Equations of state: virial equations, van-der-Waals equation, generalized equations of state 5. Mixing properties: ideal and real mixtures, excess properties, partial molar properties 6. Vapor-liquid-equilibria: binary systems, azeotropes, equilibrium condition 7. Gas-liquid-equilibria: equilibrium condition, Henry-coefficient 8. G^E-Models: Hildebrand-model, Flory-Huggins-model, Wilson-model, UNIQUAC, UNIFAC 9. Liquid-liquid-equilibria: equilibrium condition, phase equilibria in binary and ternary systems 10. Solid-liquid-equilibria: equilibrium condition, binary systems 11. Chemical reactions: reaction coordinate, mass action law, influence of pressure and temperature 12. Osmotic pressure 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 • J.M. Prausnitz, R.N. Lichtenthaler, E.G. de Azevedo: Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed. Prentice Hall, 1999. • 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 2. Thermodynamic equations in multi-component systems: Fundamental equations, chemical potential, fugacity 3. Phase equilibria of pure substances: thermodynamic equilibrium, vapor pressure, Gibbs' phase rule 4. Equations of state: virial equations, van-der-Waals equation, generalized equations of state 5. Mixing properties: ideal and real mixtures, excess properties, partial molar properties 6. Vapor-liquid-equilibria: binary systems, azeotropes, equilibrium condition 7. Gas-liquid-equilibria: equilibrium condition, Henry-coefficient 8. G^E-Models: Hildebrand-model, Flory-Huggins-model, Wilson-model, UNIQUAC, UNIFAC 9. Liquid-liquid-equilibria: equilibrium condition, phase equilibria in binary and ternary systems 10. Solid-liquid-equilibria: equilibrium condition, binary systems 11. Chemical reactions: reaction coordinate, mass action law, influence of pressure and temperature 12. Osmotic pressure
Literature	• Jürgen Gmehling, Bärbel Kolbe: Thermodynamik. VCH 1992 • J.M. Prausnitz, R.N. Lichtenthaler, E.G. de Azevedo: Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd ed. Prentice Hall, 1999. • 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**: No; **Bonus**: 5 %; **Form**: Midterm; **Description**:
Examination	Written exam
Examination duration and scale	3 hours
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory

Course L0091: Fundamentals of Fluid Mechanics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	SoSe
Content	• fluid properties • hydrostatic • overall balances - theory of streamline • overall balances- conservation equations • differential balances - Navier Stokes equations • irrotational flows - Potenzialströmungen • flow around bodies - theory of physical similarity • turbulent flows • compressible flows
Literature	1. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 2. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 3. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994 4. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006 5. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008 6. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007 7. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2009 8. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007 9. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008 10. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006 11. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882. 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) Herbert Oertel, Martin Böhle, Thomas Reviol: Strömungsmechanik für Ingenieure und Naturwissenschaftler, Springer Verlag, Berlin, ISBN: 978-3-658-07786-0 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. 2. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 3. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994 4. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006 5. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008 6. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007 7. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2009 8. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007 9. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008 10. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006 11. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882. 12. White, F.: Fluid Mechanics, Mcgraw-Hill, ISBN-10: 0071311211, ISBN-13: 978-0071311212, 2011

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 • 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 • 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 • The students can use different graphical methods for the designing of a separation process and define the amount of theoretical stages required • 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 • The students are capable to obtain independently the needed material properties from appropriate sources (diagrams and tables) • They can calculate continuous and discontinuous processes • The students are able to prove their theoretical knowledge in the experimental lab work. • The students are able to discuss the theoretical background and the content of the experimental work with the teachers in colloquium. 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 • 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 • 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 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: Specialisation Energy Systems / Renewable Energies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory Process Engineering: Core Qualification: Compulsory

Course L0118: Thermal Separation Processes	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Irina Smirnova
Language	DE
Cycle	WiSe
Content	• Introduction in the thermal process engineering and to the main features of separation processes • Simple equilibrium processes, several steps processes • Distillation of binary mixtures, enthalpy-concentration diagrams • Extractive and azeotrope distillation, water vapor distillation, stepwise distillation • Extraction: separation ternary systems, ternary diagram • Multiphase separation including complex mixtures • Designing of separation devices without discrete stages • Drying • Chromatographic separation processes • Membrane separation • Energy demand of separation processes • Advance overview of separation processes • Selection of separation processes
Literature	• G. Brunner: Skriptum Thermische Verfahrenstechnik • J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980 • Sattler: Thermische Trennverfahren, VCH, Weinheim 1995 • J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998. • Mersmann: Thermische Verfahrenstechnik, Springer, 1980 • Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997 • 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 . • R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006. ◦ 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 • Simple equilibrium processes, several steps processes • Distillation of binary mixtures, enthalpy-concentration diagrams • Extractive and azeotrope distillation, water vapor distillation, stepwise distillation • Extraction: separation ternary systems, ternary diagram • Multiphase separation including complex mixtures • Designing of separation devices without discrete stages • Drying • Chromatographic separation processes • Membrane separation • Energy demand of separation processes • Advance overview of separation processes • Selection of separation processes The students work on tasks in small groups and present their results in front of all students.
Literature	• G. Brunner: Skriptum Thermische Verfahrenstechnik • J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980 • Sattler: Thermische Trennverfahren, VCH, Weinheim 1995 • J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998. • Mersmann: Thermische Verfahrenstechnik, Springer, 1980 • Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997 • 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 . • R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006. • 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 • Simple equilibrium processes, several steps processes • Distillation of binary mixtures, enthalpy-concentration diagrams • Extractive and azeotrope distillation, water vapor distillation, stepwise distillation • Extraction: separation ternary systems, ternary diagram • Multiphase separation including complex mixtures • Designing of separation devices without discrete stages • Drying • Chromatographic separation processes • Membrane separation • Energy demand of separation processes • Advance overview of separation processes • Selection of separation processes
Literature	• G. Brunner: Skriptum Thermische Verfahrenstechnik • J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980 • Sattler: Thermische Trennverfahren, VCH, Weinheim 1995 • J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998. • Mersmann: Thermische Verfahrenstechnik, Springer, 1980 • Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997 • 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 . • R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006. • 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. 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. Topics of the practical course: • Introduction in the thermal process engineering and to the main features of separation processes • Simple equilibrium processes, several steps processes • Distillation of binary mixtures, enthalpy-concentration diagrams • Extractive and azeotrope distillation, water vapor distillation, stepwise distillation • Extraction: separation ternary systems, ternary diagram • Multiphase separation including complex mixtures • Designing of separation devices without discrete stages • Drying • Chromatographic separation processes • Membrane separation • Energy demand of separation processes • Advance overview of separation processes • Selection of separation processes
Literature	• G. Brunner: Skriptum Thermische Verfahrenstechnik • J. King: Separation Processes, McGraw-Hill, 2. Aufl. 1980 • Sattler: Thermische Trennverfahren, VCH, Weinheim 1995 • J.D. Seader, E.J. Henley: Separation Process Principles, Wiley, New York, 1998. • Mersmann: Thermische Verfahrenstechnik, Springer, 1980 • Grassmann, Widmer, Sinn: Einführung in die Thermische Verfahrenstechnik, 3. Aufl., Walter de Gruyter, Berlin 1997 • 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 . • R. Goedecke (Hrsg.): Fluid-Verfahrenstechnik, Wiley-VCH Verlag, Weinheim, 2006. • 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). • They are capable of distinguish and characterize different kinds of heat transfer mechanisms namely heat conduction, heat transfer and thermal radiation. • 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. • 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. • 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. • Using dimensionless quantities, the students can execute scaling up of technical processes or apparatus. • 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). • 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. • In addition, they can calculate both, steady-state and non-steady-state processes in procedural apparatus. • 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 • 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 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 Technomathematics: Specialisation III. Engineering Science: Elective Compulsory 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 ∘ Introduction, one-dimensional heat conduction ∘ Convective heat transfer ∘ Multidimensional heat conduction ∘ Non-steady heat conduction ∘ Thermal radiation 2. Mass transfer ∘ one-way diffusion, equimolar countercurrent diffusion ∘ boundary layer theory, non-steady mass transfer ∘ Heat and mass transfer single particle/ fixed bed ∘ Mass transfer and chemical reactions
Literature	1. H.D. Baehr und K. Stephan: Wärme- und Stoffübertragung, Springer 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 • They can explain the dynamics of simple control loops and interpret dynamic properties in terms of frequency response and root locus • They can explain the Nyquist stability criterion and the stability margins derived from it. • They can explain the role of the phase margin in analysis and synthesis of control loops • They can explain the way a PID controller affects a control loop in terms of its frequency response • 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 • They can simulate and assess the behavior of systems and control loops • They can design PID controllers with the help of heuristic (Ziegler-Nichols) tuning rules • They can analyze and synthesize simple control loops with the help of root locus and frequency response techniques • They can calculate discrete-time approximations of controllers designed in continuous-time and use it for digital implementation • 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. 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 Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Data Science: Specialisation II. Application: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Logistics and Mobility: Specialisation Information Technology: Elective Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory 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 • Linear systems, differential equations and transfer functions • First and second order systems, poles and zeros, impulse and step response • Stability Feedback systems • Principle of feedback, open-loop versus closed-loop control • Reference tracking and disturbance rejection • Types of feedback, PID control • System type and steady-state error, error constants • Internal model principle Root locus techniques • Root locus plots • Root locus design of PID controllers Frequency response techniques • Bode diagram • Minimum and non-minimum phase systems • Nyquist plot, Nyquist stability criterion, phase and gain margin • Loop shaping, lead lag compensation • Frequency response interpretation of PID control Time delay systems • Root locus and frequency response of time delay systems • Smith predictor Digital control • Sampled-data systems, difference equations • Tustin approximation, digital implementation of PID controllers Software tools • Introduction to Matlab, Simulink, Control toolbox • Computer-based exercises throughout the course
Literature	• Werner, H., Lecture Notes „Introduction to Control Systems“ • G.F. Franklin, J.D. Powell and A. Emami-Naeini "Feedback Control of Dynamic Systems", Addison Wesley, Reading, MA, 2009 • K. Ogata "Modern Control Engineering", Fourth Edition, Prentice Hall, Upper Saddle River, NJ, 2010 • 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 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 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 • Cost estimates and cost calculations; definitions; cost calculation; cost estimation; calculation of costs for provision of work and power • Economic calculation; definitions; methods: static methods, dynamic methods; project view versus view from the overall economy; power and work in economic calculation • Consideration of uncertainties in projects; definitions; technical uncertainties; cost uncertainties; other uncertainties • Cost projections; approaches and methods; assessment of uncertainties • 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 • name and explain processes and unit-operations of solids process engineering, • characterize particles, particle distributions and to discuss their bulk properties
Skills	Students are able to • choose and design apparatuses and processes for solids processing according to the desired solids properties of the product • asses solids with respect to their behavior in solids processing steps • 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 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: Specialisation Water Technologies: Elective Compulsory 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 • Description of a separation process • Description of a particle mixture • Particle size reduction • Agglomeration, particle size enlargement • Storage and flow of bulk solids • Basics of fluid/particle flows • classifying processes • Separation of particles from fluids • Basic fluid mechanics of fluidized beds • Pneumatic and hydraulic transport
Literature	Schubert, H.; Heidenreich, E.; Liepe, F.; Neeße, T.: Mechanische Verfahrenstechnik. Deutscher Verlag für die Grundstoffindustrie, Leipzig, 1990. 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 • Bulk properties • Size reduction • Mixing • Gas cyclone • Blaine-test, filtration • Sedimentation
Literature	Schubert, H.; Heidenreich, E.; Liepe, F.; Neeße, T.: Mechanische Verfahrenstechnik. Deutscher Verlag für die Grundstoffindustrie, Leipzig, 1990. 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 - classify and formulate global balance equations and linear material balance models for process engineering systems - understand and apply system concepts - explain and apply strategies for the synthesis of reactors in the synthesis of separation systems - understand PINCH analyses - specify static and dynamic methods of cost and profitability calculation - Specify static and dynamic methods of cost and profitability calculation
Skills	Students are enabled to - prepare mass and energy balances of processes and calculate the flows - calculate mass flows in complex process engineering plants with the aid of linear material balance models - solve balance equalization problems - perform structured process synthesis for reactors - perform structured process synthesis for separation systems - Carry out PINCH analyses - 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** / **Bonus** / **Form** / **Description** Yes / 10 % / Subject theoretical and practical work / No / 5 % / Midterm /
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory 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: Specialisation Biotechnologies: Elective Compulsory 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 - Global balances, flowsheets of processes, balance compensation and data validation Process synthesis - Structure of process engineering processes, decision levels in process development, reactor synthesis, synthesis of separation processes, alternatives and selection criteria, energy integration Cost accounting and project management 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 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 • to give an overview of the basic genetic processes in the cell • to explain basic molecularbiological methods • to give an overview of -omics strategies • to explain genetic differences between pro- and eukaryotes
Skills	Students are able to • consider safety measurements when working in the laboratory • work sterile • cultivate microorganisms aerobically • measure enzyme activity • identify microorganisms based and physiological assays and 16S rRNA encoding gene sequences • apply core knowledge of the lectures "Biochemistry" and "Microbiology" in laboratory experiments • scientific poster design and presentation
Personal Competence	
Social Competence	Students are able to • conduct laboratory experiments in teams • write protocols in teams • develop solutions for given problems • develop and distribute work assignments for given problems • present and reflect their specific knowledge in discussions with fellow students and tutors • present and discuss their own scientific poster
Autonomy	Students are able to • search information for a given problem by themselves • 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** / **Bonus** / **Form** / **Description** Yes / 20 % / Subject theoretical and practical work / 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 Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Specialisation Bio Engineering: 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 - DNA replication, transcription, translation - Regulation of gene expression - Mechanisms of gene transfer, recombination, transposition - Mutatuion and DNA repair - DNA cloning - DNA sequencing - Polymerase chain reaction - Genome sequencing, (meta)genomics, transcriptomics, proteomics
Literature	Rolf Knippers, **Molekulare Genetik**, Georg Thieme Verlag Stuttgart Munk, K. (ed.), **Genetik**, 2010, Thieme Verlag John Ringo, **Genetik kompakt**, 2006, Elsevier GmbH, München T. A. Brown, **Gene und Genome**, 2007, 3. Aufl., Spektrum Akademischer Verlag, 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. 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. 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. Topics and Methods of the course include: - Morphology and growth of different bacteria strains - Measuring of microbial growth by turbidity - Preparation of several culture media - Strain identification by gram staining and analytical profile index (API test) - Genetic background identification by 16S rRNA analysis - Microscopy - BLAST analyses - Colony PCR procedure - Enzyme activity measurements and kinetics (Michaelis-Menten equation, Lineweaver-Burk plot) - Enzymes as biocatalysts (exemplarily use of enzymes in detergents) - Measurement of protein concentrations (Bradford protein assay) - Qualitative and quantitative enzyme activity assay
Literature	Brock Mikrobiologie / Brock Microbiology (Michael T. Madigan, John M. Martinko) 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" • Content of module "Bioprocess Technology I" • 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 • explain the microbial, energetic and engineering principles of biotechnological production processes, • assess substance transport effects in heterogeneous processes with immobilized enzymes and cells • classify and apply approaches to mathematical modeling of biotechnological processes • explain the essential features of typical bioreactors and select suitable bioreactors for different biotechnological production processes, • understand and quantify transport phenomena in bioreactors and consider them for bioprocess scale-up • explain and design typical downstream processes for bio-processes, • identify specific scientific problems and solutions for different types of fermentation processes • classify the legal framework for handling biological materials.
Skills	After successful completion of this module, students should be able to • to identify scientific questions or possible practical problems for concrete industrial applications (e.g. cultivation of microorganisms and animal cells) and to formulate solutions, • evaluate heterogeneous processes with immobilized enzymes and cells with regard to mass transport effects • 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), • 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 • Medium design and optimization, sterilization • mathematical description of material transport effects in heterogeneous reactions with immobilized enzymes, microorganisms or cells • Basic concepts for mathematical models for bio-processes • Bioreactors - concepts, design, control, operation, scale-up • Downstream processing in biotechnological production processes • Selected biotechnological production processes (e.g. antibiotics, amino acids, therapeutic antibodies) • Repititorium
Literature	P. F. Stanbury, A. Whitaker, S. J. Hall, Principles of Fermentation Technology, 3 rd. Edition, Butterworth-Heinemann, 2016. H. Chmiel, R. Takors, D. Weuster-Botz (Herausgeber): Bioprozeßtechnik, Springer Spektrum, 2018 R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010 H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997 P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013 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 • Medium design and optimization, sterilization • Mass transport effects for immobilised enzymes, microorganisms and cells • Bioreactors - design, scale-up • Downstream processing in biotechnological production processes • Selected biotechnological production processes (e.g. antibiotics, amino acids, therapeutic antibodies) 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. H. Chmiel, R. Takors, D. Weuster-Botz (Herausgeber): Bioprozeßtechnik, Springer Spektrum, 2018 R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010 H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997 P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013 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" • Content of module “Fundamentals in Molecular Biology” • Content of module "Bioprocess Technology I" • 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 • the relevant strategies for the design and scale-up of a production plant for a microbial processes (up-stream), • the relevant features of typical bioreactors for selection of suitable bioreactors for different biotechnological production processes, • process strategies for fermentation processes, • tools for the optimization of process strategies, • the peculiarities and solution approaches for different biotechnological production processes.
Skills	After successful completion of this module, students should be able to • explain and apply the relevant strategies for the design and scale-up of a production plant for a microbial processes (up-stream), • explain the relevant features of typical bioreactors and select suitable bioreactors for different biotechnological production processes, • explain and select process strategies for fermentation processes, • apply tools for the optimization of process strategies, • 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.). 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 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 • 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 Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Compulsory Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory 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 • Atomic structure and bonding • Structure of solids • Miller indices • Imperfections in solids • Texture • Diffusion • Mechanical properties • Dislocations and strengthening mechanisms • Phase transformations • Phase diagrams, iron-carbon phase diagram • Metallic materials • Corrosion • Polymeric materials • Ceramic materials
Literature	• Bargel, H.-J.; Schulze, G. (Hrsg.): Werkstoffkunde. Berlin u.a., Springer Vieweg, 2012. • Bergmann, W.: Werkstofftechnik 1. München u.a., Hanser, 2009. • Bergmann, W.: Werkstofftechnik 2. München u.a., Hanser, 2008. • Callister, W. D.; Rethwisch, D. G.: Materialwissenschaften und Werkstofftechnik: eine Einführung, Übersetzungshrsg.: Scheffler, M., 1. Auflage, Weinheim, Wiley-VCH, 2013. • 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: • give an overview of a certain important field on process and bioprocess engineering, • explain some working methods for different fields in process engineering.
Skills	After successfully completing this module, students are able to • prepare a written summary of a process engineering topic • to briefly present and discuss a topic in a short presentation • to roughly describe independently typical process engineering and biotechnological processes by means of notes.
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	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 Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory 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: • Internships in industry (e.g. also during the semester break) • Completed practical projects with construction and workshop activities (basic internship) at institutes of the faculty • Activities on experimental plants at institutes of the faculty • Own project in the student workshop • 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: • Ring-Lectures • VT Colloquia • Presentations of Master Thesises 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 2. Knowledge of biological relationships and substance groups 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 - explain the legal framework for biotechnological and chemical work, - 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, - Assign genetic engineering work and equipment in biotechnological genetic laboratories according to the security level, - 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 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. 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. Topics covered in the course: - Genome sequencing on a MinION - De novo genome assembly - Metagenome analyses - Functional and taxonomic annotation of gene sequences - Construction of phylogenetic trees - Representation of metabolic pathways - Genome mining - 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 Engineering Science: Specialisation Chemical and Bioprocess Engineering, Focus Bio Engineering: Compulsory 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: • Genome sequencing on a MinION • De novo genome assembly • Metagenome analyses • Functional and taxonomic annotation of gene sequences • Construction of phylogenetic trees • Representation of metabolic pathways • Genome mining • 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 • explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management • explain the most important aspects of and goals in Management and name the most important aspects of entreprneurial projects • 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 • 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 • 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 • analyse Management goals and structure them appropriately • analyse organisational and staff structures of companies • apply methods for decision making under multiple objectives, under uncertainty and under risk • analyse production and procurement systems and Business information systems • analyse and apply basic methods of marketing • select and apply basic methods from mathematical finance to predefined problems • apply basic methods from accounting, costing and controlling to predefined problems
Personal Competence	
Social Competence	Students are able to • work successfully in a team of students • to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project • to communicate appropriately and • to cooperate respectfully with their fellow students.
Autonomy	Students are able to • work in a team and to organize the team themselves • 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 Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory Computer Science in Engineering: Core Qualification: Compulsory Logistics and Mobility: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Mechanical Engineering: Specialisation Energy Systems: Compulsory Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory

	Mechanical Engineering: Specialisation Product Development and Production: Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory Mechanical Engineering: Specialisation Mechatronics: Compulsory Mechatronics: Core Qualification: Compulsory Mechatronics: Specialisation Electrical Systems: Compulsory Mechatronics: Specialisation Dynamic Systems and AI: Compulsory Mechatronics: Specialisation Medical Engineering: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory Mechatronics: Specialisation Naval Engineering: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory 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. 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 • Important definitions from Management, • Developing Objectives for Business, and their relation to important Business functions • Business Functions: Functions of the Value Chain, e.g. Production and Procurement, Supply Chain Management, Innovation Management, Marketing and Sales Cross-sectional Functions, e.g. Organisation, Human Ressource Management, Supply Chain Management, Information Management • Definitions as information, information systems, aspects of data security and strategic information systems • Definition and Relevance of innovations, e.g. innovation opporunities, risks etc. • Relevance of marketing, B2B vs. B2C-Marketing • different techniques from the field of marketing (e.g. scenario technique), pricing strategies • important organizational structures • basics of human ressource management • Introduction to Business Planning and the steps of a planning process • Decision Analysis: Elements of decision problems and methods for solving decision problems • Selected Planning Tasks, e.g. Investment and Financial Decisions • Introduction to Accounting: Accounting, Balance-Sheets, Costing • Relevance of Controlling and selected Controlling methods • Important aspects of Entrepreneurship projects
Literature	Bamberg, G., Coenenberg, A.: Betriebswirtschaftliche Entscheidungslehre, 14. Aufl., München 2008 Eisenführ, F., Weber, M.: Rationales Entscheiden, 4. Aufl., Berlin et al. 2003 Heinhold, M.: Buchführung in Fallbeispielen, 10. Aufl., Stuttgart 2006. Kruschwitz, L.: Finanzmathematik. 3. Auflage, München 2001. Pellens, B., Fülbier, R. U., Gassen, J., Sellhorn, T.: Internationale Rechnungslegung, 7. Aufl., Stuttgart 2008. Schweitzer, M.: Planung und Steuerung, in: Bea/Friedl/Schweitzer: Allgemeine Betriebswirtschaftslehre, Bd. 2: Führung, 9. Aufl., Stuttgart 2005. Weber, J., Schäffer, U. : Einführung in das Controlling, 12. Auflage, Stuttgart 2008. 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. 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	150 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory 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) • Overview of today's alternative fuels o Biodiesel / HEFA o Bioethanol o Biomethane o Other fuels • Overview of future alternative fuels o 2nd generation biofuels o Hydrogen and hydrogen derivatives o Electricity-based fuels o Other fuels • Electromobility o with battery o with hydrogen fuel cell • Markets and market developments • CO2 analyses of the various options per application area • Global megatrends and future challenges • Developments in vehicle and drive technologies • Energy scenarios up to 2050 and significance for the mobility sector
Literature	Eigene Unterlagen, Veröffentlichungen, Fachliteratur 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. Possible tasks in the field of renewable energies are: • Solar thermal heat • Concentrating solare power • Photovoltaic • Windenergie • Hydropower • Heat pump 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 (a) heat generation from biogenic solid fuels in small and large-scale plants (b) power generation from solid biomass via combustion (c) a biogas production from residues, by-products and waste, (d) alcohol production from sugar and starch (e) biodiesel production from vegetable oils. 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 • Engineering Mechanics I (Stereostatics) • Engineering Mechanics II (Elastostatics) • Measurement Technology for Chemical and Bioprocess Engineerin • 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. • Students can reproduce fundamentals of design, strength of material calculation and material selection for elements of process equipment. • Students can reproduce basic principles of connecting and combining elements of apparatuses. • 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. • Students are capable to calculate wall thickness of simple elements. • Students are capable to design bolted flange connections. • 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. • 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 Orientation Studies: Core Qualification: Elective Compulsory 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 • Basic materials for process engineering • Examples of apparatuses and their elements • Construction conforming to standards of technical drawings and flow diagram • Perspective illustration of pipe systems and apparatus elements • Boiler formula • Stresses and strains of thick-walled cylindrical shells • Wall thickness calculations of thin-walled cylindrical shells applying mechanical strength criterion and equivalent stresses • System flange-bolt-gasket, sealings • Shaft-hub connections • Bearings • Screwed connections • Welded connections • Heat exchangers
Literature	• Bargel, H.-J.; Schulze, G. (Hrsg.): Werkstoffkunde. Berlin u.a., Springer Vieweg, 2012. • Bergmann, W.: Werkstofftechnik 1. München u.a., Hanser, 2009. • Bergmann, W.: Werkstofftechnik 2. München u.a., Hanser, 2008. • Callister, W. D.; Rethwisch, D. G.: Materialwissenschaften und Werkstofftechnik: eine Einführung, Übersetzungshrsg.: Scheffler, M., 1. Auflage, Weinheim, Wiley-VCH, 2013. • Klapp, E.: Apparate- und Anlagentechnik, Springer, Berlin, 2002. • Tietze, W.: Taschenbuch Dichtungstechnik, Vulkan, Essen, 2005. • Titze, H., Wilke, H.-P.: Elemente des Apparatebaus, Springer, Berlin, 1992. • Schwaigerer, S., Mühlenbeck, G.: Festigkeitsberechnung im Dampfkessel-, Behälter- und Rohrleitungsbau, Springer, Berlin, 1997. • Seidel, W. W.,Hahn, F.: Werkstofftechnik. München u.a., Hanser, 2012. • Wagner, W.: Festigkeitsberechnungen im Apparate- und Rohrleitungsbau, Würzburg, Vogel, 2007. • 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 • Basic materials for process engineering • Examples of apparatuses and their elements • Construction conforming to standards of technical drawings and flow diagram • Perspective illustration of pipe systems and apparatus elements • Boiler formula • Stresses and strains of thick-walled cylindrical shells • Wall thickness calculations of thin-walled cylindrical shells applying mechanical strength criterion and equivalent stresses • System flange-bolt-gasket, sealings • Shaft-hub connections • Bearings • Screwed connections • Welded connections • Heat exchangers
Literature	• Bargel, H.-J.; Schulze, G. (Hrsg.): Werkstoffkunde. Berlin u.a., Springer Vieweg, 2012. • Bergmann, W.: Werkstofftechnik 1. München u.a., Hanser, 2009. • Bergmann, W.: Werkstofftechnik 2. München u.a., Hanser, 2008. • Callister, W. D.; Rethwisch, D. G.: Materialwissenschaften und Werkstofftechnik: eine Einführung, Übersetzungshrsg.: Scheffler, M., 1. Auflage, Weinheim, Wiley-VCH, 2013. • Klapp, E.: Apparate- und Anlagentechnik, Springer, Berlin, 2002. • Tietze, W.: Taschenbuch Dichtungstechnik, Vulkan, Essen, 2005. • Titze, H., Wilke, H.-P.: Elemente des Apparatebaus, Springer, Berlin, 1992. • Schwaigerer, S., Mühlenbeck, G.: Festigkeitsberechnung im Dampfkessel-, Behälter- und Rohrleitungsbau, Springer, Berlin, 1997. • Seidel, W. W.,Hahn, F.: Werkstofftechnik. München u.a., Hanser, 2012. • Wagner, W.: Festigkeitsberechnungen im Apparate- und Rohrleitungsbau, Würzburg, Vogel, 2007. • 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 • 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 Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Compulsory Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory 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 • Atomic structure and bonding • Structure of solids • Miller indices • Imperfections in solids • Texture • Diffusion • Mechanical properties • Dislocations and strengthening mechanisms • Phase transformations • Phase diagrams, iron-carbon phase diagram • Metallic materials • Corrosion • Polymeric materials • Ceramic materials
Literature	• Bargel, H.-J.; Schulze, G. (Hrsg.): Werkstoffkunde. Berlin u.a., Springer Vieweg, 2012. • Bergmann, W.: Werkstofftechnik 1. München u.a., Hanser, 2009. • Bergmann, W.: Werkstofftechnik 2. München u.a., Hanser, 2008. • Callister, W. D.; Rethwisch, D. G.: Materialwissenschaften und Werkstofftechnik: eine Einführung, Übersetzungshrsg.: Scheffler, M., 1. Auflage, Weinheim, Wiley-VCH, 2013. • 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: • give an overview of a certain important field on process and bioprocess engineering, • explain some working methods for different fields in process engineering.
Skills	After successfully completing this module, students are able to • prepare a written summary of a process engineering topic • to briefly present and discuss a topic in a short presentation • to roughly describe independently typical process engineering and biotechnological processes by means of notes.
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	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 Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory Engineering Science: Specialisation Chemical and Bioprocess Engineering: Compulsory 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: • Internships in industry (e.g. also during the semester break) • Completed practical projects with construction and workshop activities (basic internship) at institutes of the faculty • Activities on experimental plants at institutes of the faculty • Own project in the student workshop • 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: • Ring-Lectures • VT Colloquia • Presentations of Master Thesises 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 • basic knowledge of stoichiometry • basic knowledge of chemical thermodynamics, in particular chemical equilibrium • basic knowledge of measurement technology (temperature, pressure, measurement of concentrations) • basic knowledge of chemical reaction engineering (plug flow reactor, batch reactor, continuously stirred tank reactor) • 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 • 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,) • know about experimental methods to measure the kinetics of chemical reactions on various time scales and can explain how they work • can recognize and sketch concentration time profiles of parallel-, consecutive- and equilibrium reactions • know about the differential and integral method of kinetic analysis and the method of half-life times • know the mathematical shape of rate laws of heterogeneously catalyzed reactions • know about reactions that oscillate in time and space and can explain the origin of these oscillations
Skills	students • can formulate and integrate differential rate laws of chemical reactions either analytically or numerically • can integrate sink- and source terms of chemical species in models of chemical reactors and couple them with the kinetics of the reactions • can plan and perform kinetic measurements • can analyze measured kinetic data and determine kinetic parameters (reaction orders, pre-exponential factors, activation energies) • formulate reaction networks and simplify them with tools like sensitivity analysis and reaction path analysis • 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 • 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 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 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) 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) 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 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 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. 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). 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. 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 2. Chemical Kinetics and Reaction Dynamics, P. L. Houston, Dover 3. Chemical Kinetics, K. J. Laidler, Harper & Row 4. Reaction Kinetics, M. J. Pilling, P. W. Seakins, Oxford Science Publications 5. Kinetics and Mechanism, J. W. Moore, R. G. Pearson, John Wiley & Sons 6. Chemical Kinetics and Dynamics, J. I. Steinfeld, J. S. Francisco, W. L. Hase, Prentice Hall 7. Chemically Reacting Flow, R. J. Kee, M. E. Coltrin, P. Glarborg, Wiley Interscience 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 • explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management • explain the most important aspects of and goals in Management and name the most important aspects of entreprneurial projects • 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 • 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 • 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 • analyse Management goals and structure them appropriately • analyse organisational and staff structures of companies • apply methods for decision making under multiple objectives, under uncertainty and under risk • analyse production and procurement systems and Business information systems • analyse and apply basic methods of marketing • select and apply basic methods from mathematical finance to predefined problems • apply basic methods from accounting, costing and controlling to predefined problems
Personal Competence	
Social Competence	Students are able to • work successfully in a team of students • to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project • to communicate appropriately and • to cooperate respectfully with their fellow students.
Autonomy	Students are able to • work in a team and to organize the team themselves • 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 Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory Computer Science in Engineering: Core Qualification: Compulsory Logistics and Mobility: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Mechanical Engineering: Specialisation Energy Systems: Compulsory Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory

	Mechanical Engineering: Specialisation Product Development and Production: Compulsory
	Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory
	Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory
	Mechanical Engineering: Specialisation Mechatronics: Compulsory
	Mechatronics: Core Qualification: Compulsory
	Mechatronics: Specialisation Electrical Systems: Compulsory
	Mechatronics: Specialisation Dynamic Systems and AI: Compulsory
	Mechatronics: Specialisation Medical Engineering: Compulsory
	Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory
	Mechatronics: Specialisation Naval Engineering: Compulsory
	Orientation Studies: Core Qualification: Elective Compulsory
	Orientation Studies: Core Qualification: Elective Compulsory
	Naval Architecture: Core Qualification: Compulsory
	Technomathematics: Core Qualification: Compulsory
	Process Engineering: Core Qualification: Compulsory
	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. 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 • Important definitions from Management, • Developing Objectives for Business, and their relation to important Business functions • Business Functions: Functions of the Value Chain, e.g. Production and Procurement, Supply Chain Management, Innovation Management, Marketing and Sales Cross-sectional Functions, e.g. Organisation, Human Ressource Management, Supply Chain Management, Information Management • Definitions as information, information systems, aspects of data security and strategic information systems • Definition and Relevance of innovations, e.g. innovation opporunities, risks etc. • Relevance of marketing, B2B vs. B2C-Marketing • different techniques from the field of marketing (e.g. scenario technique), pricing strategies • important organizational structures • basics of human ressource management • Introduction to Business Planning and the steps of a planning process • Decision Analysis: Elements of decision problems and methods for solving decision problems • Selected Planning Tasks, e.g. Investment and Financial Decisions • Introduction to Accounting: Accounting, Balance-Sheets, Costing • Relevance of Controlling and selected Controlling methods • Important aspects of Entrepreneurship projects
Literature	Bamberg, G., Coenenberg, A.: Betriebswirtschaftliche Entscheidungslehre, 14. Aufl., München 2008 Eisenführ, F., Weber, M.: Rationales Entscheiden, 4. Aufl., Berlin et al. 2003 Heinhold, M.: Buchführung in Fallbeispielen, 10. Aufl., Stuttgart 2006. Kruschwitz, L.: Finanzmathematik. 3. Auflage, München 2001. Pellens, B., Fülbier, R. U., Gassen, J., Sellhorn, T.: Internationale Rechnungslegung, 7. Aufl., Stuttgart 2008. Schweitzer, M.: Planung und Steuerung, in: Bea/Friedl/Schweitzer: Allgemeine Betriebswirtschaftslehre, Bd. 2: Führung, 9. Aufl., Stuttgart 2005. Weber, J., Schäffer, U. : Einführung in das Controlling, 12. Auflage, Stuttgart 2008. Weber, J./Weißenberger, B.: Einführung in das Rechnungswesen, 7. Auflage, Stuttgart 2006.

Thesis

Module M-001: Bachelor Thesis

Courses			
Title	**Typ**	**Hrs/wk**	**CP**

Module Responsible	Professoren der TUHH
Admission Requirements	• According to General Regulations §21 (1): At least 126 ECTS credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• The students can select, outline and, if need be, critically discuss the most important scientific fundamentals of their course of study (facts, theories, and methods). • On the basis of their fundamental knowledge of their subject the students are capable in relation to a specific issue of opening up and establishing links with extended specialized expertise. • The students are able to outline the state of research on a selected issue in their subject area.
Skills	• The students can make targeted use of the basic knowledge of their subject that they have acquired in their studies to solve subject-related problems. • With the aid of the methods they have learnt during their studies the students can analyze problems, make decisions on technical issues, and develop solutions. • The students can take up a critical position on the findings of their own research work from a specialized perspective.
Personal Competence	
Social Competence	• Both in writing and orally the students can outline a scientific issue for an expert audience accurately, understandably and in a structured way. • The students can deal with issues in an expert discussion and answer them in a manner that is appropriate to the addressees. In doing so they can uphold their own assessments and viewpoints convincingly.
Autonomy	• The students are capable of structuring an extensive work process in terms of time and of dealing with an issue within a specified time frame. • The students are able to identify, open up, and connect knowledge and material necessary for working on a scientific problem. • The students can apply the essential techniques of scientific work to research of their own.
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0
Credit points	12
Course achievement	None
Examination	Thesis
Examination duration and scale	According to General Regulations
Assignment for the Following Curricula	General Engineering Science (German program): Thesis: Compulsory General Engineering Science (German program, 7 semester): Thesis: Compulsory Civil- and Environmental Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Data Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Engineering Science: Thesis: Compulsory General Engineering Science (English program): Thesis: Compulsory General Engineering Science (English program, 7 semester): Thesis: Compulsory Green Technologies: Energy, Water, Climate: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Logistics and Mobility: Thesis: Compulsory Mechanical Engineering: Thesis: Compulsory Mechatronics: Thesis: Compulsory Naval Architecture: Thesis: Compulsory Technomathematics: Thesis: Compulsory Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory Process Engineering: Thesis: Compulsory Engineering and Management - Major in Logistics and Mobility: Thesis: Compulsory