TUHH
Hamburg
University of
Technology

Module Manual

Bachelor of Science (B.Sc.)

Green Technologies: Energy, Water, Climate

Cohort: Winter Term 2021

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Program description

Content

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

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

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

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

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

Career prospects

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

Learning target

The bachelor's degree programme Green Technologies: Energy, Water, Climate is designed to prepare students both for a professional activity and for a relevant consecutive master's degree programme. The basic methodological knowledge required for this is acquired during the study programme. The learning objectives of the degree programme are achieved through an interplay of basic and advanced modules from mechanical engineering, process engineering, hydraulic engineering and renewable energies.
Through the participation of professional engineers from industry in lectures, through experimental laboratory practicals and the exchange with lecturers from the University of Hamburg in the field of climate and meteorology, the students are able to develop a realistic relationship to the diverse professional field of climate, environmental, water and energy technology during their studies. This significantly increases the graduates' later career opportunities and enables them to help shape our world of tomorrow.
Graduates will be able to responsibly and competently perform an engineering job in various fields of activity in green and future-oriented technologies. In addition, they acquire the necessary scientific knowledge for a subsequent, in-depth Master's degree, which can be studied consecutively based on the chosen specialisation.
Knowledge
The knowledge acquired during the study programme enables graduates to understand the phenomena occurring in the subject areas of green technologies and related disciplines. They have understood the basic principles of climate, urban water management, conventional and renewable energy systems, with particular reference to sustainability and environmental protection. Knowledge is constituted by facts, principles and theories and is acquired in the Bachelor's degree programme Green Technologies in the following areas:
- Graduates are able to reproduce basic knowledge in the scientific and engineering fields of mathematics, chemistry, mechanics, thermodynamics, fluid mechanics, computer science, electrical engineering, control engineering and heat and mass transfer.
- Graduates are able to outline and discuss fundamental methods and procedures for solving or approximating iterative decision and optimisation problems, such as differentiation, gradient-based procedures, testing hypotheses, as well as their analysis in terms of complexity, convergence and goodness.
- Through further specialised knowledge of the subject area (energy systems, water, bioresource technology or energy technology), they can further deepen their learned content with a focus on climate and environmental impact and develop procedures for solving environmental issues.
- Graduates are able to describe the construction, operation and organisation of conventional and regenerative energy plants and their components, including the control concepts used in the process. They are able to recognise the challenges of the energetically and economically optimised operation of energy plants, taking into account the additional criteria of resource conservation, sustainability, environmental compatibility and economic efficiency.
- Graduates will be able to investigate suitable technical alternatives in their professional life in order to minimise the environmental and social footprint of their engineering work and effectively support the energy transition.
- Graduates will be able to gain knowledge and skills beyond engineering for their profession through non-technical events.
Skills
The ability to apply learned knowledge to solve specific problems is supported in many ways in the Bachelor's degree programme Green Technologies:
- Graduates are able to master relevant, specialised methods and tools, to assess their predictability and complexity and to implement them using suitable programming tools from current practice.

- Graduates are able to understand and further analyse climate processes, describe facilities and processes in the field of green technologies, balance energy systems and identify technical as well as economic relationships between conventional and renewable energy technologies.
- Graduates can identify and describe environmental impacts in general and develop control strategies of environmental pollution from industrial plants. This is also based on experience from related fields of measurement technology and process and environmental engineering.
- Graduates have the ability to identify the objectives of an engineering project, a green technology operation or society for a balanced and sustainable coverage of energy, water and resource needs and to responsibly prioritise in finding the optimal solution approach.
- Graduates are able to present the approach and results of their work in writing and explain them orally. They have mastered presentation techniques and have practised technical communication.
- Graduates are able to independently plan and conduct experiments and interpret the results.
- Graduates are able to apply measurement, control and regulation technology or constructive methods.
- Graduates have the ability to develop designs for processes, machines and apparatus according to specified requirements.
Social competence
Social competence includes the individual ability and willingness to work together with others in a goal-oriented manner, to understand the interests of

others, to communicate and to help shape the working and living environment.
- Graduates can organise themselves in a professionally homogeneous team, work out a solution, take on specific subtasks and responsibly deliver partial results, and reflect on their own contribution.
- Graduates are able to discuss their scientific work results interactively and interdisciplinarily, to present them in front of the plenum and to defend them.
- Graduates are able to communicate about the contents and problems of energy and environmental technology with experts and laypersons.
Independence
Personal competences include not only the competence to act independently, but also to further develop one's own ability to act.
- Graduates can independently explore a narrowly defined sub-area of green technologies and summarise the results in detail in a presentation using common presentation techniques or in an essay of several pages. Critical analysis and not mere memorisation is required.
- Graduates are able to realistically assess their existing competences and work on deficits independently.
- Graduates are able to organise and carry out projects independently.
- Graduates are able to work independently on subject-specific sub-projects in a Bachelor's thesis using what they have learned during their studies.
- Graduates are able to independently obtain necessary information from suitable literature sources and to assess their quality.
- Graduates are able to evaluate technical problems in a larger social context and assess the non-technical effects of engineering activities.

Program structure

The curriculum of the Bachelor's degree programme Green Technologies: Energy, Water, Climate, which was designed as an undergraduate degree programme, consists mainly of compulsory courses. Elective options are provided for in the supplementary courses of the non-technical area.
In the first three semesters, the focus is on learning basic knowledge in the areas of mathematics, mechanics, chemistry, computer science, thermodynamics as well as meteorology and climate. Furthermore, the topics and applications of green technologies are taught in a module strand "Green Technologies" in the first, third and fifth semesters.
In the further course, the study programme is then expanded to include basic engineering subjects and the topics of regenerative energies as well as water supply and treatment. From the fourth semester onwards, you can choose a subject focus according to your personal interests. You can choose from the four specialisations "Energy Systems", "Water", "Bioresource Technology" or "Energy Technology".
Structure of the degree programme:
- Mathematical-scientific basics (five modules)
- Fundamentals of engineering (ten modules)
- Green Technologies: Fundamentals of Climate and Environmental Engineering (three modules)
- Engineering Applications in Water and Energy (three modules).
- Electives in the specialisations "Energy Systems", "Water", "Bioresource Technology" or "Energy Technology" (five modules)
The following content from the non-technical area is added:
- One module on business administration
- Further supplementary courses from the non-technical compulsory elective catalogue (one module)
The scope of the Bachelor's programme in Energy and Environmental Engineering thus comprises 28 modules. These are divided into 26 subject modules and two non-technical supplementary modules. The programme is based on a broad mathematical-physical and scientific foundation. It also ensures that the theoretical basic knowledge is deepened and applied in the subjects of green technologies and engineering applications. In addition, the Bachelor's thesis is the module that concludes the degree programme.

Core Qualification

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

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

Module M0850: Mathematics I

Courses

Title	Typ	Hrs/wk	CP
Analysis I (L1010)	Lecture	2	2
Analysis I (L1012)	Recitation Section (small)	1	1
Analysis I (L1013)	Recitation Section (large)	1	1
Linear Algebra I (L0912)	Lecture	2	2
Linear Algebra I (L0913)	Recitation Section (small)	1	1
Linear Algebra I (L0914)	Recitation Section (large)	1	1

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	School mathematics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in analysis and linear algebra. They are able to explain them using appropriate examples. • 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	None
Examination	Written exam
Examination duration and scale	60 min (Analysis I) + 60 min (Linear Algebra I)
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory

	Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computational Science and Engineering: 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 L1010: Analysis I	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	WiSe
Content	Foundations of differential and integrational calculus of one variable • statements, sets and functions • natural and real numbers • convergence of sequences and series • continuous and differentiable functions • mean value theorems • Taylor series • calculus • error analysis • fixpoint iteration
Literature	• http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html

Course L1012: Analysis I	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1013: Analysis I	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH, Dr. Simon Campese
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0912: Linear Algebra I	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Anusch Taraz, Prof. Marko Lindner, Dr. Dennis Clemens
Language	DE
Cycle	WiSe
Content	• vectors: intuition, rules, inner and cross product, lines and planes • systems of linear equations: Gauß elimination, matrix product, inverse matrices, transformations, block matrices, determinants • orthogonal projection in R^n, Gram-Schmidt-Orthonormalization
Literature	• T. Arens u.a. : Mathematik, Spektrum Akademischer Verlag, Heidelberg 2009 • 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 L0913: Linear Algebra I	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Anusch Taraz, Prof. Marko Lindner, Dr. Dennis Clemens
Language	DE
Cycle	WiSe
Content	• vectors: intuition, rules, inner and cross product, lines and planes • general vector spaces: subspaces, Euclidean vector spaces • systems of linear equations: Gauß-elimination, matrix product, inverse matrices, transformations, LR-decomposition, block matrices, determinants
Literature	• T. Arens u.a. : Mathematik, Spektrum Akademischer Verlag, Heidelberg 2009 • 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

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

Module M0889: Mechanics I (Statics)

Courses

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

Module Responsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	Solid school knowledge in mathematics and physics.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can • 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 Data Science: Specialisation Mechanics: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective 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 Technomathematics: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

Course L1001: Mechanics I (Statics)	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	• Tasks in Mechanics • 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 L1002: Mechanics I (Statics)	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	Forces and equilibrium 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 L1003: Mechanics I (Statics)	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	Forces and equilibrium 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 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 M0883: General and Inorganic Chemistry

Courses

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

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

Module M1692: Computer Science for Engineers - Introduction and Overview

Courses

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

Module Responsible	Prof. Görschwin Fey
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6

Course achievement	Compulsory	Bonus	Form	Description
	No	10 %	Attestation	Testate finden semesterbegleitend statt.

Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: 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 Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

Course L2685: Computer Science for Engineers - Introduction and Overview

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Görschwin Fey
Language	DE/EN
Cycle	WiSe
Content	

Literature	• Informatik
	  ◦ Helmut Herold, Bruno Lurz, Jürgen Wohlrab, Matthias Hopf: Grundlagen der Informatik, 3. Auflage, 816 Seiten, Pearson Studium, 2017.
	• C++
	  ◦ Bjarne Stroustrup, Einführung in die Programmierung mit C++, 479 Seiten, Pearson Studium, 2010.
	  --> in der englischen Version bereits eine neuere Auflage!
	  ◦ Jürgen Wolf : Grundkurs C++: C++-Programmierung verständlich erklärt, Rheinwerk Computing, 3. Auflage, 2016.

Course L2686: Computer Science for Engineers - Introduction and Overview

Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Görschwin Fey
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1711: Green Technologies I

Courses

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

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Upon completion of this module, students will be able to describe and critically evaluate current environmental and climate problems, especially in Hamburg. Furthermore, they are able to find and process suitable approaches to solutions. The students can compare learned technologies in the field of climate and environmental protection, develop and take a standpoint on them and defend it in discussions. In addition, students can give an overview of the basics of meterology and climate.
Skills	The students are able to apply the knowledge they have acquired on sustainable technologies in the area of the environmentally and climate-friendly water, energy and climate nexus in order to explain solution approaches for a supply-secure provision. Furthermore, the students are able to explain the procedures and basics on the topics of climate and meterology and apply them to renewable energy projects in the context of other modules.
Personal Competence	
Social Competence	Students can • work together in a team of about 3-5 people, • discuss tasks on the topics of environmental, resource and climate protection in a subject-specific manner and develop joint solutions, • present their own work results to fellow students and • assess the performance of fellow students in comparison to their own performance and deal with feedback on their own performance.
Autonomy	The students are able to independently access sources about the question to be worked on. They are able to assess their respective learning status in consultation with supervisors and, on this basis, define further questions and the work steps necessary to solve them.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	Compulsory: Yes; Bonus: 20 %; Form: Presentation; Description:
Examination	Written exam
Examination duration and scale	60 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory

Course L2727: Introduction to Green Technologies

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

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

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

Module M0851: Mathematics II

Courses

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

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	Mathematics I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name further concepts in analysis and linear algebra. They are able to explain them using appropriate examples. • 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	None
Examination	Written exam
Examination duration and scale	60 min (Analysis II) + 60 min (Linear Algebra II)
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computational Science and Engineering: 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 L1025: Analysis II	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	• power series and elementary functions • interpolation • integration (proper integrals, fundamental theorem, integration rules, improper integrals, parameter dependent integrals • applications of integration (volume and surface of bodies of revolution, lines and arc length, line integrals • numerical quadrature • periodic functions
Literature	• http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html

Course L1026: Analysis II	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH, Dr. Sebastian Götschel
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1027: Analysis II	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0915: Linear Algebra II	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Anusch Taraz, Prof. Marko Lindner, Dr. Dennis Clemens
Language	DE
Cycle	SoSe
Content	• general vector spaces: subspaces, Euclidean vector spaces • linear mappings: basis transformation, orthogonal projection, orthogonal matrices, householder matrices • linear regression: normal equations, linear discrete approximation • eigenvalues: diagonalising matrices, normal matrices, symmetric and Hermite matrices • system of linear differential equations • matrix factorizations: LR-decomposition, QR-decomposition, Schur decomposition, Jordan normal form, singular value decomposition
Literature	• T. Arens u.a. : Mathematik, Spektrum Akademischer Verlag, Heidelberg 2009 • 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 L0916: Linear Algebra II	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Anusch Taraz, Prof. Marko Lindner, Dr. Dennis Clemens
Language	DE
Cycle	SoSe
Content	• linear mappings: basis transformation, orthogonal projection, orthogonal matrices, householder matrices • linear regression: QR-decomposition, normal equations, linear discrete approximation • eigenvalues: diagonalising matrices, normal matrices, symmetric and Hermite matrices, Jordan normal form, singular value decomposition • system of linear differential equations
Literature	• 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

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

Module M0696: Mechanics II: Mechanics of Materials

Courses

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

Module Responsible	Prof. Christian Cyron
Admission Requirements	None
Recommended Previous Knowledge	Mechanics I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Having accomplished this module, the students know and understand the basic concepts of continuum mechanics and elastostatics, in particular stress, strain, constitutive laws, stretching, bending, torsion, failure analysis, energy methods and stability of structures.
Skills	Having accomplished this module, the students are able to - 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	-
Autonomy	-
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Data Science: Specialisation Mechanics: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Green Technologies: Energy, Water, Climate: 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 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: Mechanics II

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	SoSe
Content	stresses and strains Hooke's law tension and compression torsion bending stability buckling energy methods
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 L0494: Mechanics II	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

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

Module M0888: Organic Chemistry

Courses

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

Module Responsible	Prof. Ralph Holl
Admission Requirements	None
Recommended Previous Knowledge	High School Chemistry and/or lecture "general and inorganic chemistry"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are familiar with basic concepts of organic chemistry. They are able to classify organic molecules and to identify functional groups and to describe the respective synthesis routes. Fundamental reaction mechanisms like nucleophilic substitution, eliminations, additions and aromatic substitution can be described. Students are capable to describe in general modern reaction mechanisms.
Skills	Students are able to use basics of organic chemistry for the design of technical processes. Especially they are able to formulate basic routes to synthesize small organic molecules and by this to optimise technical processes in Process Engineering. They are able to transform a verbally formulated message into an abstract formal procedure. The students are able to document and interpret their working process and results scientifically.
Personal Competence	
Social Competence	The students are able to discuss in small groups and develop an approach for given tasks.
Autonomy	Students are able to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
Workload in Hours	Independent Study Time 82, Study Time in Lecture 98
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / None / Subject theoretical and practical work
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	Bioprocess Engineering: Core Qualification: Compulsory 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, Prof. Pierre Stallforth
Language	DE
Cycle	SoSe
Content	The lecture covers basic concepts of organic chemistry. This includes simple carbon compounds, alkanes, alkenes, aromatic compounds, alcohols, phenols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, amides and amino acids. Further, fundamentals of reaction mechanisms will be described. This includes nucleophilic substitution, eliminations, additions and aromatic substitution. Also modern reaction mechanisms will be described.
Literature	gängige einführende Werke zur Organischen Chemie. Z.B. „Organische Chemie“ von K.P.C.Vollhart & N.E.Schore, Wiley VCH

Course L0832: Organic Chemistry	
Typ	Practical Course
Hrs/wk	3
CP	2
Workload in Hours	Independent Study Time 18, Study Time in Lecture 42
Lecturer	Prof. Nina Schützenmeister, Prof. Pierre Stallforth
Language	DE
Cycle	SoSe
Content	The lecture covers basic concepts of organic chemistry. This includes simple carbon compounds, alkanes, alkenes, aromatic compounds, alcohols, phenols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, amides and amino acids. Further, fundamentals of reaction mechanisms will be described. This includes nucleophilic substitution, eliminations, additions and aromatic substitution. Also modern reaction mechanisms will be described. 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. Dr. 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 are able to discuss in small groups and develop an approach.
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: 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. Dr. 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 arbritary 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. Dr. 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. Dr. Arne Speerforck
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0608: Basics of Electrical Engineering

Courses

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

Module Responsible	Prof. Thorsten Kern
Admission Requirements	None
Recommended Previous Knowledge	Basics of mathematics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can to draw and explain circuit diagrams for electric and electronic circuits with a small number of components. They can describe the basic function of electric and electronic componentes and can present the corresponding equations. They can demonstrate the use of the standard methods for calculations.
Skills	Students are able to analyse electric and electronic circuits with few components and to calculate selected quantities in the circuits. They apply the ususal methods of the electrical engineering for this.
Personal Competence	
Social Competence	Students are enabled to collaborate in interdisciplinary teams with electrical engineering as a common language With this, they are learning communication in a target-oriented communication style, are able to understand interfaces to neighboring engineering disciplines and learn about commonalities but also limits in the different directions of engineering.
Autonomy	Students are able independently to analyse electric and electronic circuits and to calculate selected quantities in the circuits.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	135 minutes
Assignment for the Following Curricula	Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Mechanical Engineering: 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: Specialisation Production Management and Processes: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory

Course L0290: Basics of Electrical Engineering

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

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

Module M0853: Mathematics III

Courses

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

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	Mathematics I + II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in the area of analysis and differential equations. They are able to explain them using appropriate examples. • 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 • 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 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. Dr. 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 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. Dr. 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. Dr. 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. Dr. Arne Speerforck
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1497: Measurement Technology for Chemical and Bioprocess Engineering

Courses

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

Module Responsible	Prof. Alexander Penn
Admission Requirements	None
Recommended Previous Knowledge	Technical interest, logical skills, integral- and differential calculus, basic physical concepts such as temperature, mass, velocity, etc..
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Physical basics: kinematics and dynamics (theory of motion), rotation of rigid bodies, energy and momentum, electricity, magnetism, basics of hydrodynamics, temperature and heat, ideal gas. 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	Bonus	Form	Description
No	20 %	Excercises	Popup-Quizzes währen der Vorlesung

Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory 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 M1712: Green Technologies II

Courses

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

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

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

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

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

Module M0536: Fundamentals of Fluid Mechanics

Courses

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

Module Responsible	Prof. Michael Schlüter
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics I+II+III • Technical Mechanics I+II • Technical Thermodynamics I+II • Working with force balances • Simplification and solving of partial differential equations • Integration
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • explain the difference between different types of flow • give an overview for different applications of the Reynolds Transport-Theorem in process engineering • explain simplifications of the Continuity- and Navier-Stokes-Equation by using physical boundary conditions
Skills	The students are able to • describe and model incompressible flows mathematically • reduce the governing equations of fluid mechanics by simplifications to archive quantitative solutions e.g. by integration • notice the dependency between theory and technical applications • use the learned basics for fluid dynamical applications in fields of process engineering
Personal Competence	
Social Competence	The students • are capable to gather information from subject related, professional publications and relate that information to the context of the lecture and • able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises) • are able to work out solutions for exercises by themselves, to discuss the solutions orally and to present the results.
Autonomy	The students are able to • search further literature for each topic and to expand their knowledge with this literature, • work on their exercises by their own and to evaluate their actual knowledge with the feedback.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	Compulsory: 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 M0686: Sanitary Engineering I

Courses

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

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

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

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

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

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

Module M1714: Conventional Energy Systems and Energy Industry

Courses

Title	Typ	Hrs/wk	CP
Power Industry (L0316)	Lecture	1	1
Energy markets and energy trading (L2744)	Lecture	2	2
Fossil Energy Systems (L2745)	Lecture	2	2
Fossil Energy Systems (L2746)	Recitation Section (large)	1	1

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Upon completion of this module, students will be able to provide an overview of characteristics of energy systems. They can explain the issues that arise. Furthermore, they are able to explain knowledge of energy production, energy distribution and energy trade in this context, taking into account contexts bordering on other disciplines. The students can explain this knowledge, which is applicable to almost all energy systems, in particular detail for conventional energy systems and take a critical stance on them. Furthermore, they can explain the environmental impact of using conventional energy systems. They also have an overview of reserves and resources as well as global and national market volumes. This also includes the legal framework, which should especially take into account the mitigation of climate change.
Skills	Students are able to apply methodologies for determining energy demand or energy supply to different types of energy systems. Furthermore, they can evaluate energy systems technically, ecologically and economically as well as systemically and are also able to design them under certain given conditions. They are able to select the regulations necessary for this in a subject-specific manner, especially by means of non-standard solutions to a problem. Students are able to orally explain issues from the subject area and approaches to dealing with them and to classify them in the respective context.
Personal Competence	
Social Competence	The students are able to analyze suitable technical alternatives and to assess them with technical, economical and ecological criteria under sustainability aspects.
Autonomy	Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory

Course L0316: Power Industry	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Kaltschmitt, Prof. Andreas Wiese
Language	DE
Cycle	SoSe

Content	• Electrical energy in the energy system
	• Demand and use of electrical energy (households, industry, "new" buyers (including e-mobility))
	• Electricity generation
	  ◦ electricity generation technologies using fossil fuels and their characteristics
	  ◦ combined heat and power technologies and their production characteristics
	  ◦ electricity generation from renewable energy technologies and their characteristics
	• Power distribution
	  ◦ "classic" distribution of electrical energy
	  ◦ challenges of fluctuating electricity generation by distributed systems (electricity market, electricity stock exchange, emissions trading)
	• District heating industry
	• Legal and administrative aspects
	  ◦ Energy Act
	  ◦ support instruments for renewable energy
	  ◦ CHP Act
	• Cost and efficiency calculation

Literature	Folien der Vorlesung

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

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

Course L2746: Fossil Energy Systems	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	SoSe
Content	The goal of this exercise is to present and discuss the different fossil energy systems in their entirety. This includes the petroleum, natural gas, hard coal, lignite and nuclear energy systems. In each case, the formation processes, the exploration technologies, the exploration processes, the extraction technologies, the further processing processes and the corresponding utilization are presented. In addition, the respective markets and their development, the existing reserves and resources, and the environmental effects associated with extraction and utilization are discussed. A total system approach is pursued, which includes a presentation of the entire energy system including the given interdependencies and (geo)political dependencies. The current changes in these energy systems for Germany and internationally, and those that are expected to occur in the coming years, are also discussed. In addition, the respective reserve and resource availability is illuminated.
Literature	Unterlagen des Übung

Module M1715: Renewable Energies

Courses

Title	Typ	Hrs/wk	CP
Renewable Energies I (L2740)	Lecture	2	2
Renewable Energies I (L2742)	Recitation Section (large)	1	1
Renewable Energies II (L2741)	Lecture	2	2
Renewable Energies II (L2743)	Recitation Section (large)	1	1

Module Responsible	Prof. Martin Kaltschmitt
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Upon completion of this module, students will be able to provide an overview of characteristics of renewable energy systems. They will be able to explain the issues that arise in these systems. Furthermore, they are able to explain knowledge of energy supply, energy distribution and energy trading in this context, taking into account contexts bordering on specific disciplines. The students can explain this knowledge in detail for such energy systems and take a critical stand on it. Furthermore, they can explain the environmental impact of using renewable energy systems and have an overview of the economic classification of the respective options.
Skills	Students are able to apply methodologies for determining energy demand or energy supply to different types of renewable energy systems. Furthermore, they can evaluate such energy systems technically, ecologically and economically as well as systemically and also design them under certain given conditions. They are able to select the regulations necessary for this in a subject-specific manner, especially by means of non-standard solutions to a problem. Students are able to orally explain issues from the subject area and approaches to dealing with them and to classify them in the respective context.
Personal Competence	
Social Competence	Students are able to investigate suitable technical alternatives and ultimately evaluate them based on technical, economic and ecological criteria - and thus from a sustainability perspective.
Autonomy	Students will be able to independently access sources about the field, acquire knowledge and transform it to address new issues.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory 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 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

Course L2743: Renewable Energies II	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	SoSe
Content	The students work on tasks in the field of renewable energies the field "energy from biomass". They present their solution approaches in the exercise group and discuss them with their fellow students and the teaching staff afterwards.
Literature	Unterlagen der Vorlesung

Module M1775: Economic and environmental project assessment

Courses

Title	Typ	Hrs/wk	CP
Case studies project assessment (L1054)	Recitation Section (small)	1	1
Environmental Assessment (L0860)	Lecture	2	2
Economic basics (L2918)	Lecture	2	3

Module Responsible	Prof. Martin Kaltschmitt
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	None
Examination	Written exam
Examination duration and scale	90 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 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, Dozenten des SD V
Language	DE
Cycle	WiSe
Content	**Presentation and application of free software programs in order to understand the concepts of environmental assessment methods better.** Within the group exercise students discuss the various technical and scientific tasks, both subject-specific and multidisciplinary. They discuss different approaches to the task as well as it's theoretical or practical implementation.
Literature	Power point Präsentationen

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

Course L2918: Economic basics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Justus Kellner
Language	DE
Cycle	WiSe
Content	
Literature	

Module M0538: Heat and Mass Transfer

Courses

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

Module Responsible	Prof. Irina Smirnova
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge: Technical Thermodynamics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• The students are capable of explaining qualitative and determining quantitative heat transfer in procedural apparatus (e. g. heat exchanger, chemical reactors). • 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 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 minutes; theoretical questions and calculations
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory 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 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	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Irina Smirnova
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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

Module M0833: Introduction to Control Systems

Courses

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

Module Responsible	Prof. Herbert Werner
Admission Requirements	None
Recommended Previous Knowledge	Representation of signals and systems in time and frequency domain, Laplace transform
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can represent dynamic system behavior in time and frequency domain, and can in particular explain properties of first and second order systems • 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: Core Qualification: Elective 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 Integrated Building Technology: Core Qualification: Elective 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 Information Technology: Elective 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

Course L0654: Introduction to Control Systems	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	DE
Cycle	WiSe
Content	Signals and systems • 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. Herbert Werner
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Specialization Bioresource Technology

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

Module M0757: Biochemistry and Microbiology

Courses

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

Module Responsible	Prof. Johannes Gescher
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	At the end of this module the students can: - explain the methods of biological and biochemical research to determine the properties of biomolecules - name the basic components of a living organism - explain the principles of metabolism - describe the structure of living cells -
Skills	
Personal Competence	
Social Competence	The students are able, - to gather knowledge in groups of about 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	The students are able to present the results of their subtasks in a written report
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory Orientation Studies: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

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

Course L0881: Microbiology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Johannes Gescher
Language	DE
Cycle	SoSe
Content	1. The procaryotic cell • evolution • taxonomy and specific properties of Archaea, Bacteria, and viruses • structure and properties of the cell • growth 2. Metabolism • fermentation and anaerobic respiration • methanogenesis and the anaerobic food chain • degradation of polymers • chemolithotrophy 3. Microorganisms in relation to the environment • chemotaxis and motility • Elemental cycle of carbon, nitrogen and sulfur • biofilms • symbiotic relationships • extremophiles • biotechnology
Literature	• **Allgemeine Mikrobiologie**, 8. Aufl., 2007, Fuchs, G. (Hrsg.), Thieme Verlag (54,95 €) • **Mikrobiologie**, 13 Aufl., 2013, Madigan, M., Martinko, J. M., Stahl, D. A., Clark, D. P. (Hrsg.), ehemals „Brock“, Pearson Verlag (89,95 €) • Taschenlehrbuch Biologie **Mikrobiologie**, 2008, Munk, K. (Hrsg.), Thieme Verlag • **Grundlagen der Mikrobiologie**, 4. Aufl., 2010, Cypionka, H., Springer Verlag (29,95 €), http://www.grundlagen-der-mikrobiologie.icbm.de/

Course L0888: Microbiology	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Johannes Gescher
Language	DE
Cycle	SoSe
Content	1. The procaryotic cell • evolution • taxonomy and specific properties of Archaea, Bacteria, and viruses • structure and properties of the cell • growth 2. Metabolism • fermentation and anaerobic respiration • methanogenesis and the anaerobic food chain • degradation of polymers • chemolithotrophy 3. Microorganisms in relation to the environment • chemotaxis and motility • Elemental cycle of carbon, nitrogen and sulfur • biofilms • symbiotic relationships • extremophiles • biotechnology
Literature	• **Allgemeine Mikrobiologie**, 8. Aufl., 2007, Fuchs, G. (Hrsg.), Thieme Verlag (54,95 €) • **Mikrobiologie**, 13 Aufl., 2013, Madigan, M., Martinko, J. M., Stahl, D. A., Clark, D. P. (Hrsg.), ehemals „Brock“, Pearson Verlag (89,95 €) • Taschenlehrbuch Biologie **Mikrobiologie**, 2008, Munk, K. (Hrsg.), Thieme Verlag • **Grundlagen der Mikrobiologie**, 4. Aufl., 2010, Cypionka, H., Springer Verlag (29,95 €), http://www.grundlagen-der-mikrobiologie.icbm.de/

Module M0892: Chemical Reaction Engineering

Courses

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

Module Responsible	Prof. Raimund Horn
Admission Requirements	None
Recommended Previous Knowledge	Contents of the previous modules mathematics I-III, physical chemistry, technical thermodynamics I+II as well as computational methods for engineers.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to explain basic concepts of chemical reaction engineering. They are able to point out differences between thermodynamical and kinetical processes. The students have a strong ability to outline parts of isothermal and non-isothermal ideal reactors and to describe their properties.
Skills	After successful completion of the module, students are able to: - 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 Bioresource Technology: 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 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 Green Technologies: Energy, Water, Climate: Specialisation Energy Systems: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: 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 M1713: Green Technologies III

Courses

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

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

Course L2766: Study Work Green Technologies

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

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

Module M0945: Bioprocess Engineering - Advanced

Courses

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

Module Responsible	Prof. Ralf Pörtner
Admission Requirements	None
Recommended Previous Knowledge	Content of module "Biochemisty and Microbiology" Content of module "Biochemical Engineering I"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, students should be able - explain the microbial, energetic and engineering principles of fermentation process, - explain different kinetic approaches for cell growth, substrate uptake and product formation and apply them for process development, - understand and quantify transport phenomena in bioreactor and consider them for bioprocess scale-up - identify specific scientific problems and solutions for different types of fermentation processes
Skills	After successful completion of this module, students should be able to - to identify scientific questions or possible practical problems for concrete industrial applications (eg cultivation of microorganisms and animal cells) and to formulate solutions , - to assess the application of scale-up criteria for different types of bioreactors and processes and to apply these criteria to given problems (anaerobic , aerobic or microaerobic bioprocesses), - to formulate questions for the analysis and optimization of real biotechnological production processes appropriate solutions, - to describe the effects of the energy generation, the regeneration of reduction equivalents , and the growth inhibition of the behavior of microorganisms and to the total fermentation process qualitatively, - to establish material balance and fermentation equations and solve them to determine the kinetic parameters of different approaches, - to select process control strategies (batch , fed-batch ,or continuous culture) appropriately and to calculate basic types and evaluate them.
Personal Competence	
Social Competence	After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork.
Autonomy	After completion of this module participants are able to acquire new sources of knowledge and apply their knowledge to previously unknown issues and to present these.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L1107: Bioprocess Engineering - Advanced	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Prof. Andreas Liese
Language	EN
Cycle	WiSe
Content	• Introduction: state-of-the-art and development trends of microbial and biocatalytic bioprocesses, introduction to the lecture • Microbial principles of fermentation, Energetic fundamentals of bioreaction • Medium design and optimization, sterilization • Kinetics of cell growth • Kinetics of substrate consumption and product formation • Material balances and metabolic flux analysis • Transport phenomena in bioreactor and bioprocess scale-u • Anaerobic fermentation process, integrated downstream processin • Microaerobic bioprocess: optimal O2 supply, process control and scale-u • Aerobic process and high cell density culture • Problem-based learning with selected bioprocesses
Literature	P. F. Stanbury, A. Whitaker, S. J. Hall, Principles of Fermentation Technology, 3 rd. Edition, Butterworth-Heinemann, 2016. H. Chmiel: Bioprozeßtechnik, Elsevier, 2006 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 Skripte für die Vorlesung

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

Module M0539: Process and Plant Engineering I

Courses

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

Module Responsible	Prof. Mirko Skiborowski
Admission Requirements	None
Recommended Previous Knowledge	unit operation of thermal an dmechanical separation processes chemical reactor eingineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	students can: classify and formulate blobal balance equations of chemical processes specify linear component equations of complex chemical processes explain linear regression and data reconcilliation problems explain pfd-diagrams
Skills	students are capable of - formulation of mass and energy balance equations and estimation of product streams - estimation of component streams of chemical plants using linear component balance models - solution of data reconcilliation tasks - conduction of process synthesis - economic evaluation of processes and the estimation of production costs
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	Compulsory: Yes; Bonus: 10 %; Form: Subject theoretical and practical work; Description:
Examination	Written exam
Examination duration and scale	120 Min. lectures notes and books
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory Process Engineering: Core Qualification: Compulsory

Course L0095: Process and Plant Engineering I

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

	Data reconciliation and data validation 3. **Process Synthesis** Decision levels Experimental process development Reactor synthesis Synthesis of separation processes (process alternatives and criteria for selection) Integration of reaction systems/separation systems (interactions, recycle streams) 4. **Process safety** 5. **Cost estimation of production plants** Production costs, capital costs, economic evaluation
Literature	S.D. Barnicki, J.R. Fair, Ind. End. Chem., 29(1990), S. 421, Ind. End. Chem., 31(1992), S. 1679 H. Becker, S. Godorr, H. Kreis, Chemical Engineering, January 2001, S. 68-74 Behr, W. Ebbers, N. Wiese, Chem. -Ing.-Tech. 72(2000)Nr. 10, S.1157 E. Blass, Entwicklung verfahrenstechnischer Prozesse, Springer-Verlag, 2. Auflage 1997 M. H. Bauer, J. Stichlmair, Chem.-Ing.-Tech., 68(1996), Nr. 8, 911-916 R. Dittmeyer, W. Keim, G. Kreysa, A. Oberholz, Chemische Technik. Prozesse und Produkte, Band 2, Neue Technologien, 5. Auflage, Wiley-VCH GmbH&Co.KGaA, Weinheim, 2004 J.M. Douglas, Conceptual Design of Chemical Processes, Mc Graw-Hill, NY, 1988 G. Fieg, Inz. Chem. Proc., 5(1979), S.15-19 G. Fieg, G. Wozny, L. Jeromin, Chem. Eng. Technol. 17(1994),5, 301-306 G. Fieg, Heat and Mass Transfer 32(1996), S. 205-213 G. Fieg, Chem. Eng. Processing, Vol. 41/2(2001), S. 123-133 U.H. Felcht, Chemie eine reife Industrie oder weiterhin Innovationsmotor, Universitätsbuchhandlung Blazek und Bergamann, Frankfurt, 2000 J.P. van Gigch, Systems Design, Modeling and Metamodeling, Plenum Press, New York, 1991 T.F. Edgar, D.M. Himmelblau, L.S. Lasdon, Optimization of Chemical Processes, McGraw-Hill, 2001 G. Gruhn, Vorlesungsmanuskript „Prozess- und Anlagentechnik, TU Hamburg-Harburg D. Hairston, Chemical Engineering, October 2001, S. 31-37 J.L.A. Koolen, Design of Simple and Robust Process Plants, Wiley-VCH, Weinheim, 2002 J. Krekel, G. Siekmann, Chem. -Ing.-Tech. 57(1985)Nr. 6, S. 511 K. Machej, G. Fieg, J. Wojcik, Inz. Chem. Proc., 2(1981), S.815-824 S. Meier, G. Kaibel, Chem. -Ing.-Tech. 62(1990)Nr. 13, S.169 J. Mittelstraß, Chem. -Ing.-Tech. 66(1994), S. 309 P. Li, M. Flender, K. Löwe, G. Wozny, G. Fieg, Fett/Lipid 100(1998), Nr. 12, S. 528-534 G. Kaibel, Dissertation, TU München, 1987 G. Kaibel, Chem.-Ing.-Tech. 61 (1989), Nr. 2, S. 104-112 G. Kaibel, Chem. Eng. Technol., 10(1987), Nr. 2, S. 92-98 H.J. Lang, Chem. Eng. 54(10),117, 1947 H.J. Lang, Chem. Eng. 55(6), 112, 1948 F. Lestak, C. Collins, Chemical Engineering, July 1997, S. 72-76

Course L0096: Process and Plant Engineering I	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mirko Skiborowski, Dr. Thomas Waluga
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1214: Process and Plant Engineering I	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Mirko Skiborowski, Dr. Thomas Waluga
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0544: Phase Equilibria Thermodynamics

Courses

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

Module Responsible	Prof. Irina Smirnova
Admission Requirements	None
Recommended Previous Knowledge	Mathematics, Physical Chemistry, Thermodynamics I and II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Starting from the very basics of thermodynamics, the students learn the mathematical tools to describe thermodynamic equilibria. • 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 Bioresource Technology: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems: 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 M0938: Bioprocess Engineering - Fundamentals

Courses

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

Module Responsible	Prof. Andreas Liese
Admission Requirements	None
Recommended Previous Knowledge	module "organic chemistry", module "fundamentals for process engineering"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail.
Skills	After successful completion of this module, students should be able to • describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters • predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentation process • analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations • distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compare them as well as to apply them to current biotechnical problem • propose solutions to complicated biotechnological problems and to deduce the corresponding models • to explore new knowledge resources and to apply the newly gained contents • identify scientific problems with concrete industrial use and to formulate solutions. • to document and discuss their procedures as well as results in a scientific manner
Personal Competence	
Social Competence	After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments.
Autonomy	After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	Compulsory: Yes; Bonus: 5 %; Form: Subject theoretical and practical work; Description:
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory

Course L0841: Bioprocess Engineering - Fundamentals	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	• Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture • Enzyme kinetics: Michaelis-Menten, differnt types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese) • Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese) • Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng) • Kinetic of subtrate consumption and product formation (Prof. Zeng) • Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese) • Transport process in a bioreactor (Prof. Zeng) • Technology of sterilization (Prof. Zeng) • Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuouse bioprocesses (Prof. Zeng/Prof. Liese) • Downstream technology in biotechnology: cell breakdown, zentrifugation, filtration, aqueous two phase systems (Prof. Liese)
Literature	K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012 H. Chmiel: Bioprozeßtechnik, Elsevier, 2006 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

Course L0842: Bioprocess Engineering- Fundamentals	
Typ	Recitation Section (large)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	1. Introduction (Prof. Liese, Prof. Zeng) 2. Enzymatic kinetics (Prof. Liese) 3. Stoichiometry I + II (Prof. Liese) 4. Microbial Kinetics I+II (Prof. Zeng) 5. Rheology (Prof. Liese) 6. Mass transfer in bioprocess (Prof. Zeng) 7. Continuous culture (Chemostat) (Prof. Zeng) 8. Sterilisation (Prof. Zeng) 9. Downstream processing (Prof. Liese) 10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)
Literature	siehe Vorlesung

Course L0843: Bioprocess Engineering - Fundamental Practical Course	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out. The students document their experiments and results in a protocol.
Literature	Skript

Specialization Energy Systems

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

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

Courses

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

Module Responsible	Prof. Sibylle Fröschle
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *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 Electrical Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical 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: Elective Compulsory Logistics and Mobility: Specialisation Information Technology: Compulsory Mechatronics: Core Qualification: 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 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 Green Technologies: Energy, Water, Climate: Specialisation Energy Systems: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: 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 M0639: Gas and Steam Power Plants

Courses

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

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

Course achievement

Compulsory	Bonus	Form	Description
No	5 %	Written elaboration	Zusammenfassung von Literatur
No	5 %	Presentation	15-minütiges, unbenotetes Testat über EBSILON Professional; nur bestanden/nicht bestanden (keine anteiligen Punkte)
No	5 %	Excercises	10 Übungsaufgaben im Laufe der Vorlesungen à 5 Minuten; bis zu 5 % Bonus je nach Anteil richtiger Abgaben
No	5 %	Group discussion	gemeinsame Erarbeitung von Inhalten

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

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

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

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

Courses

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

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

Course L1670: Electrical Power Systems I: Introduction to Electrical Power Systems	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe

Content	• fundamentals and current development trends in electric power engineering
	• tasks and history of electric power systems
	• symmetric three-phase systems
	• fundamentals and modelling of eletric power systems
	  ◦ lines
	  ◦ transformers
	  ◦ synchronous machines
	  ◦ induction machines
	  ◦ loads and compensation
	  ◦ grid structures and substations
	• fundamentals of energy conversion
	  ◦ electro-mechanical energy conversion
	  ◦ thermodynamics
	  ◦ power station technology
	  ◦ renewable energy conversion systems
	• steady-state network calculation
	  ◦ network modelling
	  ◦ load flow calculation
	  ◦ (n-1)-criterion
	• symmetric failure calculations, short-circuit power
	• control in networks and power stations
	• grid protection
	• grid planning
	• power economy fundamentals

Literature	K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013 A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017 R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008

Course L1671: Electrical Power Systems I: Introduction to Electrical Power Systems	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe

Content	• fundamentals and current development trends in electric power engineering
	• tasks and history of electric power systems
	• symmetric three-phase systems
	• fundamentals and modelling of eletric power systems
	  ◦ lines
	  ◦ transformers
	  ◦ synchronous machines
	  ◦ induction machines
	  ◦ loads and compensation
	  ◦ grid structures and substations
	• fundamentals of energy conversion
	  ◦ electro-mechanical energy conversion
	  ◦ thermodynamics
	  ◦ power station technology
	  ◦ renewable energy conversion systems
	• steady-state network calculation
	  ◦ network modelling
	  ◦ load flow calculation
	  ◦ (n-1)-criterion
	• symmetric failure calculations, short-circuit power
	• control in networks and power stations
	• grid protection
	• grid planning
	• power economy fundamentals

Literature	K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013 A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017 R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008

Module M1713: Green Technologies III

Courses

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

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

Course L2766: Study Work Green Technologies

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

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

Module M1726: System Integration Renewable Energies

Courses

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

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

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

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

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

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

Module M1745: Climate physics

Courses

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

Module Responsible	Prof. Dr. Stefan Bühler
Admission Requirements	None
Recommended Previous Knowledge	- obligatory: none - Recommended: basic knowledge of mathematics and physics acquired in the beginning semesters and knowledge from Introduction to Meteorology. Expertise in climate physics and statistics is not required.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The lecture "Climate Physics" starts with the definition of the terms climate and climate system. Then other important terms such as climate forcing and climate feedback are clarified. We then examine the Earth's radiative budget, which ultimately determines climate. Chapter 3 deals with the central issue of climate sensitivity, how much does the planet warm for a given radiative forcing? This leads to the important topic of climate feedbacks, which are discussed in the following chapters: Water Vapor, Temperature Gradient, and Ice Albedo in Chapter 4, then Clouds and Biosphere in Chapter 5. Chapter 6 deals with the Ocean and Cryosphere subsystems and their role in the climate system. Then comes the topic of material cycles in chapter 7, with a particular focus on the cycles of water and carbon. The carbon cycle provides a natural perspective on the entire Earth system history, the topic of the eighth and last lecture chapter. In the exercises the acquired knowledge is used to solve simple problems.
Skills	The students are familiar with the basic thinking and methods of climate physics and meteorological statistics. They know the importance of the different climate system components in the climate system and have understood the material cycles in the climate system (water, carbon cycle). They are able to qualitatively record processes in the climate system (trends, fluctuations). They are familiar with the basic methods of climate system analysis and know which model types can be used to describe the dynamics of the climate system.
Personal Competence	
Social Competence	Students will be able to discuss problems in the topics of climate physics with each other.
Autonomy	Students will be able to independently access sources and acquire knowledge based on the lecture focus on the subject area. Furthermore, students will be able to research further physical effects related to climate on their own.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Green Technologies: Energy, Water, Climate: Specialisation Energy Systems: Elective Compulsory

Course L2833: Climate physics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Dr. Stefan Bühler
Language	DE/EN
Cycle	WiSe
Content	In the first chapter, we clarify important terms such as climate, climate system, climate forcing, and climate feedback. We then examine the Earth's radiative budget, which ultimately determines climate. Chapter 3 deals with the central issue of climate sensitivity, how much does the planet warm for a given radiative forcing? This leads to the important topic of climate feedbacks, which are discussed in the following chapters: Water Vapor, Temperature Gradient, and Ice Albedo in Chapter 4, then Clouds and Biosphere in Chapter 5. Chapter 6 deals with the Ocean and Cryosphere subsystems and their role in the climate system. Then comes the topic of material cycles in Chapter 7, focusing primarily on the cycles of water and carbon. From the carbon cycle comes a natural perspective on the overall Earth system history, the topic of the eighth and final lecture chapter. **Learning Objective:** This lecture provides a basic understanding of the physics of the climate system and the dynamics of the climate system throughout Earth history.
Literature	**Literatur**: Dennis Hartmann, Global Physical Climatology (2nd Edition), Elsevier, 2016 Raymond Pierrehumbert, Principles of Planetary Climate, Cambridge University Press, 2010 Wallace, J. M., & Hobbs, P. V. 2006, Atmospheric science: an introductory survey (2nd Edition), Academic press. Peixoto and Oort, Physics of Climate, AIP, 1992

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

Module M1719: Climate change impact & mitigation

Courses

Title	Typ	Hrs/wk	CP
Metereology of climate change (L2749)	Lecture	2	2
Technical measures to mitigate climate change (L2747)	Lecture	2	2
Technical measures to mitigate climate change (L2748)	Recitation Section (small)	2	2

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

Course L2749: Metereology of climate change

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

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

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

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

Module M0544: Phase Equilibria Thermodynamics

Courses

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

Module Responsible	Prof. Irina Smirnova
Admission Requirements	None
Recommended Previous Knowledge	Mathematics, Physical Chemistry, Thermodynamics I and II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Starting from the very basics of thermodynamics, the students learn the mathematical tools to describe thermodynamic equilibria. • 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 Bioresource Technology: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems: 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.

Specialization Energy Technology

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

Module M0594: Fundamentals of Mechanical Engineering Design

Courses

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

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

Course L0258: Fundamentals of Mechanical Engineering Design	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Dieter Krause, Prof. Otto von Estorff, Prof. Sören Ehlers
Language	DE
Cycle	SoSe

Content	**Lecture**
	• Introduction to design
	• Introduction to the following machine elements
	  ◦ Screws
	  ◦ Shaft-hub joints
	  ◦ Rolling contact bearings
	  ◦ Welding / adhesive / solder joints
	  ◦ Springs
	  ◦ Axes & shafts
	• Presentation of technical objects (technical drawing)
	Exercise
	• Calculation methods for dimensioning the following machine elements:
	  ◦ Screws
	  ◦ Shaft-hub joints
	  ◦ Rolling contact bearings
	  ◦ Welding / adhesive / solder joints
	  ◦ Springs
	  ◦ Axis & shafts

Literature	• Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage. • Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage. • Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage. • Einführung in die DIN-Normen; Klein, M., Teubner-Verlag. • Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage. • Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage. • Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage. • Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage. • Sowie weitere Bücher zu speziellen Themen

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

Module M0933: Fundamentals of Materials Science

Courses

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

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

Course L1085: Fundamentals of Materials Science I	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jörg Weißmüller
Language	DE
Cycle	WiSe
Content	
Literature	Vorlesungsskript W.D. Callister: Materials Science and Engineering - An Introduction. 5th ed., John Wiley & Sons, Inc., New York, 2000, ISBN 0-471-32013-7 P. Haasen: Physikalische Metallkunde. Springer 1994

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

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

Module M1804: Engineering Mechanics III (Dynamics)

Courses

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

Module Responsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	Mathematics I, II, Engineering Mechanics I (Statics). Parallel to Engineering Mechanik III the module Mathematics III should be attended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can • describe the axiomatic procedure used in mechanical contexts; • explain important steps in model design; • present technical knowledge in kinematics, kinetics and vibrations.
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 kinematic, kinetic and vibraton methods to engineering problems; • estimate the reach and boundaries of kinematic, kinetic and vibraton methods and extend them to be applicable to wider problem sets.
Personal Competence	
Social Competence	The students can work in groups and support each other to overcome difficulties.
Autonomy	Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	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 Data Science: Core Qualification: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L1134: Engineering Mechanics III (Dynamics)	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	Kinematics 1.1 Motion of a particle 1.2 Planar motion of a rigid body 1.3 Spatial motion of a rigid body 1.4 Spatial relative Kinematics 2 Kinetics 2.1 Linear momentum and change of linear momentum 2.2 Angular momentum and change of angular momentum 2.3 Kinetics of rigid bodies 2.4 Energy and balance of energy 3 Vibrations 3.1 Classification of Vibrations 3.2 Free undamped vibration 3.3 Free damped vibration 3.4 Forced vibration 4 Kinetics of gyroscopes 4.1 Free gyroscopic motion 4.2 Forced gyroscopic motion
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 3 und 4. 11. Auflage, Springer (2011).

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

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

Module M1713: Green Technologies III

Courses

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

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

Course L2766: Study Work Green Technologies

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

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

Module M0639: Gas and Steam Power Plants

Courses

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

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

Course achievement

Compulsory	Bonus	Form	Description
No	5 %	Written elaboration	Zusammenfassung von Literatur
No	5 %	Presentation	15-minütiges, unbenotetes Testat über EBSILON Professional; nur bestanden/nicht bestanden (keine anteiligen Punkte)
No	5 %	Excercises	10 Übungsaufgaben im Laufe der Vorlesungen à 5 Minuten; bis zu 5 % Bonus je nach Anteil richtiger Abgaben
No	5 %	Group discussion	gemeinsame Erarbeitung von Inhalten

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

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

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

Module M1022: Reciprocating Machinery

Courses

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

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

Course L0633: Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	WiSe

Content	• Verbrennungsmotoren
	  ◦ Historischer Rückblick
	  ◦ Einteilung der Verbrennungsmotoren
	  ◦ Arbeitsverfahren
	  ◦ Vergleichsprozesse
	  ◦ Arbeit, Mitteldrücke, Leistungen
	  ◦ Arbeitsprozess des wirklichen Motors
	  ◦ Wirkungsgrade
	  ◦ Gemischbildung und Verbrennung
	  ◦ Motorkennfeld und Betriebskennlinien
	  ◦ Abgasentgiftung
	  ◦ Gaswechsel
	  ◦ Aufladung
	  ◦ Kühl- und Schmiersystem
	  ◦ Kräfte im Triebwerk
	• Kolbenverdichter
	  ◦ Thermodynamik des Kolbenverdichters
	  ◦ Einteilung und Verwendung
	• Kolbenpumpen
	  ◦ Prinzip der Kolbenpumpen
	  ◦ Einteilung und Verwendung

Literature	• A. Urlaub: Verbrennungsmotoren • W. Kalide: Kraft- und Arbeitsmaschinen

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

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

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

Module M0598: Mechanical Engineering: Design

Courses

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

Module Responsible: Prof. Dieter Krause

Admission Requirements: None

Recommended Previous Knowledge

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

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

Professional Competence

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

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

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

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

Personal Competence

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

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

Autonomy: Students are able

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

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

Credit points: 6

Course achievement

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

Examination: Written exam

Examination duration and scale: 180

Assignment for the Following Curricula

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

Course L0268: Embodiment Design and 3D-CAD Introduction and Practical Training	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	WiSe

Content	• Basics of 3D CAD technology
	• Practical course to apply a 3D CAD system
	  ◦ Introduction to the system
	  ◦ Sketching and creation of components
	  ◦ Creation of assemblies
	  ◦ Deriving technical drawings

Literature	• CAx für Ingenieure eine praxisbezogene Einführung; Vajna, S., Weber, C., Bley, H., Zeman, K.; Springer-Verlag, aktuelle Auflage. • Handbuch Konstruktion; Rieg, F., Steinhilper, R.; Hanser; aktuelle Auflage. • Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage. • Technisches Zeichnen: Grundlagen, Normen, Beispiele, Darstellende Geometrie, Hoischen, H; Hesser, W; Cornelsen, aktuelle Auflage. • Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage. • Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage. • Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage. • Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage. • Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage. • Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage.

Course L0695: Mechanical Design Project I	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	2
Workload in Hours	Independent Study Time 18, Study Time in Lecture 42
Lecturer	Prof. Thorsten Schüppstuhl
Language	DE
Cycle	WiSe

Content	• Create a technical documentation of an existing mechanical model
	• Consolidation of the following aspects of technical drawings:
	  ◦ Presentation of technical objects and standardized parts
	  (bearings, seals, shaft-hub joints, detachable connections, springs, axes and shafts)
	  ◦ Sectional views
	  ◦ Dimensioning
	  ◦ Tolerances and surface specifications
	  ◦ Creating a tally sheet

Literature	1. Hoischen, H.; Hesser, W.: Technisches Zeichnen. Grundlagen, Normen, Beispiele, darstellende Geometrie, 33. Auflage. Berlin 2011. 2. Labisch, S.; Weber, C.: Technisches Zeichnen. Selbstständig lernen und effektiv üben, 4. Auflage. Wiesbaden 2008. 3. Fischer, U.: Tabellenbuch Metall, 43. Auflage. Haan-Gruiten 2005.

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

Course L0267: Team Project Design Methodology	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	SoSe

Content	• Introduction to engineering designing methodology
	• Team Project Design Methodology
	  ◦ Creating requirement lists
	  ◦ Problem formulation
	  ◦ Creating functional structures
	  ◦ Finding solutions
	  ◦ Evaluation of the found concepts
	  ◦ Documentation of the taken methodological steps and the concepts using presentation slides

Literature	• Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage. • Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage. • Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage. • Einführung in die DIN-Normen; Klein, M., Teubner-Verlag. • Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage. • Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage. • Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage. • Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage. • Sowie weitere Bücher zu speziellen Themen

Module M0610: Electrical Machines and Actuators

Courses

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

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

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

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

Module M0725: Production Engineering

Courses

Title	Typ	Hrs/wk	CP
Production Engineering II (L0610)	Lecture	2	2
Production Engineering II (L0611)	Recitation Section (large)	1	1

Module Responsible	Prof. Wolfgang Hintze
Admission Requirements	None
Recommended Previous Knowledge	no course assessments required internship recommended
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to ... • name basic criteria for the selection of manufacturing processes. • name the main groups of Manufacturing Technology. • name the application areas of different manufacturing processes. • name boundaries, advantages and disadvantages of the different manufacturing process. • describe elements, geometric properties and kinematic variables and requirements for tools, workpiece and process. • explain the essential models of manufacturing technology.
Skills	Students are able to... • select manufacturing processes in accordance with the requirements. • design manufacturing processes for simple tasks to meet the required tolerances of the component to be produced. • assess components in terms of their production-oriented construction.
Personal Competence	
Social Competence	Students are able to ... • develop solutions in a production environment with qualified personnel at technical level and represent decisions.
Autonomy	Students are able to .. • interpret independently the manufacturing process. • assess own strengths and weaknesses in general. • assess their learning progress and define gaps to be improved. • assess possible consequences of their actions.
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Mechanical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Compulsory

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

Course L0611: Production Engineering II	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Wolfgang Hintze, Prof. Claus Emmelmann
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Specialization Water

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

Module M1727: Hydrology and Geoinformation Systems

Courses

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

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	?
Assignment for the Following Curricula	Green Technologies: Energy, Water, Climate: Specialisation Water: Elective Compulsory

Course L2465: Introduction to Geoinformation Science

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

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

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

Module M1627: Water and Environment

Courses

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

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

Course L2462: Project on Water, Environment, Traffic

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

Course L2461: Water in the Environment

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

Module M1722: New Trends in Water and Environmental Research

Courses

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

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

Course L2755: Introduction to Microplastics in Environment	
Typ	Integrated Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	WiSe
Content	Introduction - course objectives, expectations and format; Source of microplastics in environment; Microplastics sampling; Characterization of microplastics; Fate and distribution of microplastics in terrestrial environments; Effects of microplastics on terrestrial environments; Health risks of microplastics in environments
Literature	1- Characterization and Analysis of Microplastics, Volume 75 1st Edition Series Volume Editors: Teresa Rocha-Santos Armando Duarte Elsevier, published in 2017 2- Microplastic Pollutants 1st Edition Authors: Christopher Blair Crawford, Brian Quinn Elsevier Science, published in 2016 3- Microplastics in Terrestrial Environments Authors: Defu He and Yongming Luo Springer, published in 2020, DOI https://doi.org/10.1007/978-3-030-56271-7

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

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

Module M0869: Hydraulic Engineering

Courses

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

Module Responsible	Prof. Peter Fröhle
Admission Requirements	None
Recommended Previous Knowledge	Hydraulic Engineering I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to define the basic terms of hydraulic engineering and hydraulics. They are able to explain the application of basic hydrodynamic formulations (conservation laws) to practical hydraulic engineering problems. Besides this, the students can illustrate important tasks of hydraulic engineering and give an overview over river engineering, flood protection, hydraulic power engineering and waterways engineering.
Skills	The students are able to apply hydraulic engineering methods and approaches to basic practical problems and design respective hydraulic engineering systems. Besides this, they are able to use and apply established approaches of hydraulics and determine water surfaces of channel flows, influences of constructions (weirs, etc.) on channel flows as well as flow conditions of pipe system. Furthermore, they are able to run, explain and document basic hydraulic experiments.
Personal Competence	
Social Competence	The students are able to deploy their gained knowledge in applied problems. Additionaly, they will be able to work in team with engineers of other disciplines in a goal-orientated, structured manner. They can explain their results by use of peer learning approaches.
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems. Furthermore, they are capable of organising their individual work flow to contribute to the conduct of experiments and to present discipline-specific knowledge.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description**: Yes / None / Subject theoretical and practical work / Durchführung, Dokumentation und Präsentation zu einem Versuchs Hydromechanik oder Hydraulik
Examination	Written exam
Examination duration and scale	The duration of the examination is 2 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Water and Environmental Engineering: Elective Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Water: Elective Compulsory

Course L0957: Hydraulics

Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	WiSe/SoSe

Content	Flow of incompressible fluids in pipes and open channels
	• Hydraulics of pipes
	• Punps in hydraulic systems
	• Open channel flow
	• Regulative construction in open channel flow
	  ◦ Weirs
	  ◦ Sliding panels
	  ◦ Cross-section reduction by constructions

Literature	Zanke, Ulrich C. , Hydraulik für den WasserbauUrsprünglich erschienen unter: Schröder/Zanke "Technische Hydraulik", Springer-Verlag, 2003 Naudascher, E.: Hydraulik der Gerinne und Gerinnebauwerke, Springer, 1992

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

Course L0959: Hydraulic Engineering	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	WiSe/SoSe

Content	Fundamentals of hydraulic engineering
	• Introduction and hydrological cycle
	• River engineering
	  ◦ Regime theory of natural rivers
	  ◦ Sediment transport
	  ◦ Regulation of rivers
	  ◦ Bank protection / protection of river bed
	  ◦ Tidal rivers
	• Flood protection
	  ◦ Dikes
	  ◦ Flood contraol basins
	• Hydraulic power
	• Inland waterways engineering
	  ◦ waterways
	  ◦ Locks and ship lifts
	  ◦ Fish passages
	• Nature-oriented hydraulic engineering

Literature	Strobl, T. & Zunic, F: Wasserbau, Springer 2006 Patt, H. & Gonsowski, P: Wasserbau, Springer 2011

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

Module M1713: Green Technologies III

Courses

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

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

Course L2766: Study Work Green Technologies

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

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

Module M0670: Particle Technology and Solids Process Engineering

Courses

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

Module Responsible	Prof. Stefan Heinrich
Admission Requirements	None
Recommended Previous Knowledge	keine
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of the module students are able to • 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 Green Technologies: Energy, Water, Climate: Specialisation Water: 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 M1632: Applied Water Management

Courses

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

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

Course L2472: Nature-oriented Hydraulic Engineering

Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Peter Fröhle
Language	DE
Cycle	SoSe
Content	• Regime-theory and application for the development of environmental guiding priciples of rivers • Engineering-biological measures for the stabilization of rivers • design techniques for water engineering • hydraulic dimensioning of river bed and bank protection • design principles and design techniques for fish passages (fish ladder, ramps etc.)
Literature	

Course L2471: Numerical modelling of soil water dynamics	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Hannes Nevermann
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L2470: Numerical modelling of soil water dynamics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Nima Shokri
Language	EN
Cycle	SoSe
Content	• Hydrologic water bilance • aquifertyps • groundwater velocities • Darcy law • groundwater contour lines • storage capacity • flow equation • pumping tests • method of Beyer • solute transport in groundwater • Basics and theoretical background of simulation methods for the analysis of water movement in vadose zone • groundwater recharge
Literature	Todd, K. (2005): Groundwater Hydrology Fetter, C. W. (2001): Applied Hydrogeology Hölting, B. & Coldewey, W. (2005): Hydrogeologie Charbeneau, R. J. (2000): Groundwater Hydraulics and pollutant Transport

Module M1630: Sanitary Engineering II

Courses

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

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

Course L2467: Management of Wastewater Infrastructure	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Otterpohl
Language	DE
Cycle	SoSe
Content	The seminar ""Infrastructure Management Wastewater"" develops the understanding of infrastructure systems in relation to wastewater systems, but also addresses other infrastructure systems. Initially, an overview of the entire system is given, including water catchment areas, water distribution, the origin of wastewater in households and industry, stormwater runoff management, and the treatment and reuse of water (constituents). Thereby the design tools especially of digital modelling are understood by practical application. Energetic considerations as well as planning and restoration of pipeline systems are covered. For wastewater treatment, the basis developed in Sanitary Engineering I will be deepened and significantly expanded, especially the resource recovery of nutrients and water. Sanitary solutions for different socio-economic and climatic conditions are understood and calculated.
Literature	Gujer, W. (2007): Siedlungswasserwirtschaft, Springer, Berlin Heidelberg Metcalf and Eddy (2003): Wastewater Engineering : Treatment and Reuse, Boston, McGraw-Hill Henze, M. (1997): Wastewater Treatment : Biological and Chemical Processes, Berlin, Springer Stein D., Stein R. (2014): Instandhaltung von Kanalisationen, Verlag Prof. Dr.-Ing. Stein & Partner GmbH Wossog, G. (2016): Handbuch für den Rohrleitungsbau Band 1 und 2 Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall (2009): Abwasserableitung : Bemessungsgrundlagen, Regenwasserbewirtschaftung, Fremdwasser, Netzsanierung, Grundstücksentwässerung, Weimar, Univ.-Verl. DWA Arbeitsblätter

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

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 Digital Mechanical Engineering: 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 Integrated Building Technology: Thesis: Compulsory Logistics and Mobility: Thesis: Compulsory Mechanical Engineering: Thesis: Compulsory Mechatronics: Thesis: Compulsory Naval Architecture: Thesis: Compulsory

	Technomathematics: Thesis: Compulsory Teilstudiengang Lehramt Elektrotechnik-Informationstechnik: Thesis: Compulsory Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory Process Engineering: Thesis: Compulsory Engineering and Management - Major in Logistics and Mobility: Thesis: Compulsory