TUHH
Technische Universität Hamburg-Harburg

Module Manual

Bachelor of Science

Bioprocess Engineering

Cohort: Winter Term 2015

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Program description

Content

Knowledge

Graduates are able to recount basic knowledge in the areas of mathematics, physics, biology, chemistry, and mechanics. They can explain phenomena that occur in bioprocess engineering and allied disciplines. They can outline the basic bioprocess engineering principles for interpreting, modeling, and simulating biological processes and chemical reactions, energy, material, and momentum transport processes, micro-, meso- and macro-scale separation processes, and for operating the plant required for these processes. They are able to describe the basics of measurement and control technology. They can take into consideration legal aspects that arise in connection with process engineering and production facilities.

Skills

On successful completion of the program, graduates have acquired the competence to analyze and resolve issues of bioprocess engineering methodically in terms of basic principles. They are able to:

- Penetrate, analyze, and evaluate biological transformation processes (with cells and enzymes) at the molecular and process levels.
- Design bioprocesses to specified requirements.
- Choose and apply suitable analytical, modeling, simulation, and optimization methods.
- Use bioprocess engineering techniques and methods and assess their limits.
- Plan and undertake experiments independently and to interpret the results.

Social Competence

Graduates are qualified to:

- Collaborate with professionals or specialists in other disciplines and to present the findings of their work orally and in writing in a way that is understandable.
- Communicate in German and English with specialists and non-specialists on contents and problems of bioprocess engineering.
- Work independently both on their own and in (international) groups.

Self-reliance

Graduates have acquired the skills required to:

- Apply their knowledge responsibly in different areas taking security, ecological and economic considerations into account and intensify it independently.
- Assess the non-technical repercussions of engineering activity.
- Undertake literature research and use databases and other sources of information for their work.
- Organize and carry out projects.

Core qualification

Module M0569: Engineering Mechanics I

Courses

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

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

Course L0187: Engineering Mechanics I

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Uwe Weltin
Language	DE
Cycle	WiSe
Content	Methods to calculate forces in statically determined systems of rigid bodies • Newton-Euler-Method • Energy-Methods Fundamentals of elasticity • Forces and deformations in elastic systems
Literature	• Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 1: Statik, Springer Vieweg, 2013 • Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 2: Elastostatik, Springer Verlag, 2011 • Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 1: Statik, Springer Vieweg, 2013 • Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 2: Elastostatik, Springer Verlag, 2011 • Hibbeler, Russel C.: Technische Mechanik 1 Statik, Pearson Studium, 2012 • Hibbeler, Russel C.: Technische Mechanik 2 Festigkeitslehre, Pearson Studium, 2013 • Hauger, W.; Mannl, V.; Wall, W.A.; Werner, E.: Aufgaben zu Technische Mechanik 1-3: Statik, Elastostatik, Kinetik, Springer Verlag, 2011

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

Module M0577: Nontechnical Complementary Courses for Bachelors

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 Elective Study Area** 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 "non-technical department" 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, communication studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way. The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal-oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations. **The Competence Level** of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc. This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life. **Specialized Competence (Knowledge)** Students can • locate selected specialized areas with the relevant non-technical mother discipline, • outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area, • different specialist disciplines relate to their own discipline and differentiate it as well as make connections, • sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity, • Can communicate in a foreign language in a manner appropriate to the subject.
Skills	**Professional Competence (Skills)** In selected sub-areas students can • apply basic methods of the said scientific disciplines, • auestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline, • to handle simple questions in aforementioned scientific disciplines in a sucsessful manner, • justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.
Personal Competence	
Social Competence	**Personal Competences (Social Skills)** Students will be able

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

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

Module M0850: Mathematics I

Courses

Title	Typ	Hrs/wk	CP
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
Examination	Written exam
Examination duration and scale	60 min (Analysis I) + 60 min (Linear Algebra I)
Assignment for the Following Curricula	General Engineering Science (German program): Core qualification: Compulsory Civil- and Environmental Engineering: Core qualification: Compulsory Bioprocess Engineering: Core qualification: Compulsory Electrical Engineering: Core qualification: Compulsory Energy and Environmental Engineering: 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 Naval Architecture: Core qualification: Compulsory Process Engineering: Core qualification: Compulsory

Course L1010: Analysis I	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	WiSe
Content	Foundations of differential and integrational calculus of one variable • 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	• R. Ansorge, H. J. Oberle: Mathematik für Ingenieure, Band 1. Verlag Wiley-VCH, Berlin, Weinheim, New York, 2000 • H.J. Oberle, K. Rothe, Th. Sonar: Mathematik für Ingenieure, Band 3: Aufgaben und Lösungen. Verlag Wiley-VCH, Berlin, Weinheim, New York, 2000.

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

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

Course L0912: Linear Algebra I	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Anusch Taraz
Language	DE
Cycle	WiSe
Content	• vectors: intuition, rules, inner and cross product, lines and planes • general vector spaces: subspaces, isomorphic spaces, Euclidean vector spaces • systems of linear equations: Gauß-elimination, matrix product, inverse matrices, transformations, LR-decomposition, block matrices, determinants
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 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
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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	Prof. Anusch Taraz
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0886: Fundamentals of Process Engineering

Courses

Title	Typ	Hrs/wk	CP
Introduction into Process Engineering/Bioprocess Engineering (L0829)	Lecture	2	1
Fundamentals of Technical Drawing and Materials (L0830)	Lecture	1	1
Fundamentals of Technical Drawing and Materials (L1495)	Recitation Section (large)	1	2
Environmental Technologie (L0326)	Lecture	2	2

Module Responsible	Prof. Michael Schlüter
Admission Requirements	none
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After passing this module the students have the ability to: • give an overview of the most important fields on process and bioprocess engineering, • explain some working methods for different fields in process engineering.
Skills	After passing this module the students should have the ability to: • list and outline the most important fields of process engineering, • name the most important working approaches or methods of the different fields of process engineering, • read and prepare an engineering drawing, • explain the most important technologies for wastewater and exhaust air treatment • scheme typical chemical and biotechnological processes independently with the aid of pointers.
Personal Competence	
Social Competence	The students are able to • work out results in groups and document them, • provide appropriate feedback and handle feedback on their own performance constructively.
Autonomy	The students are able to estimate their progress of learning by themselves and to deliberate their lack of knowledge in Process Engineering and Bioprocess Engineering.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Chemical Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Chemical Engineering: Compulsory Technomathematics: Specialisation Engineering Science: Elective Compulsory Process Engineering: Core qualification: Compulsory

Course L0829: Introduction into Process Engineering/Bioprocess Engineering

Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dozenten des SD V
Language	DE
Cycle	WiSe
Content	Introduction into the different research fields of the subject Process Engineering and Bioprocess Engineering.
Literature	s. StudIP

Course L0830: Fundamentals of Technical Drawing and Materials	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Marko Hoffmann
Language	DE
Cycle	WiSe
Content	• Technical drawing basics (contents, kinds of drawings and generation of drawings according to relevant standards) • Projective geometry (basics, orthographic projections, isometric projections, cuts, developed views, penetration views)
Literature	• Hesser, Wilfried; Hoischen, Hans: "Technisches Zeichnen", 33., überarb. und aktualisierte Aufl, Cornelsen Verlag, Berlin, 2011 • Labisch, Susanna; Weber, Christian: "Technisches Zeichnen", 4. überarbeitete und erweiterte Auflage, Springer Vieweg Verlag, Wiesbaden, 2013 • Kurz, Ulrich; Wittel, Herbert: "Böttcher/Forberg Technisches Zeichnen", 26. überarbeitete und erweiterte Auflage, Springer Vieweg Verlag, Wiesbaden, 2014

Course L1495: Fundamentals of Technical Drawing and Materials	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dr. Marko Hoffmann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0326: Environmental Technologie	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Joachim Gerth, Prof. Martin Kaltschmitt, Prof. Kerstin Kuchta
Language	DE
Cycle	WiSe
Content	1. Introductory seminar on environmental science: 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 M0883: General and Inorganic Chemistry

Courses

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

Module Responsible	Prof. Andreas Liese
Admission Requirements	none
Recommended Previous Knowledge	High school Chemistry
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After finalization of the module students are able to describe molecular orbital theory as well as molecular interactions in the gas, liquid and solid phases. They are able to describe chemical reactions in the sense of retention of mass and energy, enthalpy and entropy as well as the chemical equilibrium. They can explain the concept of activation energy in conjucture with particle kinetic energy. They have increased knowledge of acid-base concepts, acid-base reactions in water, pH calculation, quantitative analysis (titration), redox processes in water, redox potential, Nernst theory describing the concentration dependence of redox potentials, overpotential, corrosion (local elments).
Skills	Students are able to use general and inorganic chemistry for the design of technical processes. Especially they are able to formulate mass and energy balances and by this to optimise technical processes. They are able to perform simple calculations of pH values in regard to an application of acids and bases, and evaluate the course of redox processes (calculation of redoxpotentials). They are able to transform a verbal formulated message into an abstract formal procedure. Students are able to present and discuss their scientific results in plenum.
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
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Bioprocess Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory Process Engineering: Core qualification: Compulsory

Course L0824: Fundamentals in Inorganic Chemistry

Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Gerrit A. Luinstra
Language	DE
Cycle	WiSe
Content	This elementary course in chemistry comprises the following four topics, i) molecular orbital theory applied to compounds with bonds between s-, p- and d-block elements (octahedral field only), Description of molecular interactions in the gas, liquid and solid phase, (semi) conductivity on account of the formation of band structures, ii) describing chemical reactions in the sense of retention of mass and energy, enthalpy and entropy, chemical equilibrium, concepts of activation energy in conjucture with particle kinetic energy iii) acid-base concepts, acid-base reactions in water, pH calculation, quantitative analysis (titration) iv), redox processes in water, redox potential, Nernst theory describing the concentration dependence of redox potentials, overpotential, corrosion (local elments).
Literature	Chemie für Ingenieure, Guido Kickelbick, ISBN 978-3-8273-7267-3 Chemie, Charles Mortimer (Deutsch und Englisch verfügbar) http://www.chemgapedia.de

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

Module M0920: Physics

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Physics (L0945)	Lecture	2	2
Physics (L0946)	Recitation Section (small)	1	1
Physics-Lab for VT/ BVT/ EUT (L0947)	Laboratory Course	2	3

Module Responsible	Prof. Wolfgang Hansen
Admission Requirements	none
Recommended Previous Knowledge	Elementary knowledge in Mathematics and Physics from secondary school
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to describe and explain basic terms and procedures about three-dimensional kinematics, dynamics, and thermodynamics. They can identify and apply the equations of motion for linear, circular, and oscillatory motion. They are able to reflect and interpret basic physical principles and physical concepts such as conservation laws and their implications.
Skills	The students get knowledge of basic terminology of physics and ability to employ physical laws in order to solve simple technical problems. The students can organize their experiments, record and analyse data according to the instructions.
Personal Competence	
Social Competence	The students are able to discuss and present their preparation, the practical measurement and the analysis of their physical experiments in small groups.
Autonomy	The students are able to read and comprehend literature to basic physical subjects. From the tutors they get feedback on their verbal and written work. Due to the given feedback they learn to access their level of knowledge.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Written exam
Examination duration and scale	Exam: 90 min; Physics Lab: 6 Experiments and final talk
Assignment for the Following Curricula	Bioprocess Engineering: Core qualification: Compulsory Process Engineering: Core qualification: Compulsory

Course L0945: Physics

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Wolfgang Hansen, Prof. Christian Schroer
Language	DE
Cycle	WiSe
Content	One- and multidimensional kinematics, dynamics, gravitation, work and energy, momentum, rotational motion, conservation laws, oscillatory motion, thermodynamics
Literature	Tipler, P.A.: Physik für Wissenschaftler und Ingenieure, Spektrum, 2004 Giancoli, D.C.: Physik Pearson Studium, 2006 Halliday, D.; Resnick, R.: Physik, Wiley-VCH, 2005

Course L0946: Physics

Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Wolfgang Hansen, Prof. Christian Schroer
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0947: Physics-Lab for VT/ BVT/ EUT	
Typ	Laboratory Course
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Wolfgang Hansen
Language	DE/EN
Cycle	WiSe
Content	In the physics lab a number of key experiments on physical phenomena in mechanics, oscillatory and wave motion, thermodynamics, electricity, and optics will be conducted by the students under assistance of a lecturing tutor. The experiments are part of the physics education program presented in the course "Physics for TUHH-VT Engineers". Beyond teaching of fundamental physical background the objectives are basic skills in preparation and performing physical measurements, usage of physical equipment, analysis of the results and preparation of a report on the experimental data.
Literature	Zu den Versuchen gibt es individuelle Versuchsanleitungen, die vor der Versuchsdurchführung ausgegeben werden. Zum Teil müssen die zur Versuchsdurchführung notwendigen physikalischen Hintergründe selbstständig erarbeitet werden, wozu die zur Vorlesung "Physik für TUHH-VT Ingenieure" angegebene Literatur gut geeignet ist.

Module M0570: Engineering Mechanics II

Courses

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

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

Course L0191: Engineering Mechanics II

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Uwe Weltin
Language	DE
Cycle	SoSe
Content	Method for calculation of forces and motion of rigid bodies in 3D • Newton-Euler-Method • Energy methods
Literature	• Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 2: Elastostatik, Springer Verlag, 2011 • Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 3: Kinetik, Springer Vieweg, 2012 • Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 2: Elastostatik, Springer Verlag, 2011 • Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 3: Kinetik, Springer Vieweg, 2012 • Hibbeler, Russel C.: Technische Mechanik 2 Festigkeitslehre, Pearson Studium, 2013 • Hibbeler, Russel C.: Technische Mechanik 3 Dynamik, Pearson Studium, 2012 • Hauger, W.; Mannl, V.; Wall, W.A.; Werner, E.: Aufgaben zu Technische Mechanik 1-3: Statik, Elastostatik, Kinetik, Springer Verlag, 2011

Course L0192: Engineering Mechanics II

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

Module M0671: Technical Thermodynamics I

Courses

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

Module Responsible	Prof. Gerhard Schmitz
Admission Requirements	none
Recommended Previous Knowledge	Elementary knowledge in Mathematics and Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are familiar with the laws of Thermodynamic. They know the relation of the kinds of energy according to 1st law of Thermodynamic and are aware about the limits of energy conversions according to 2nd law of Thermodynamic. 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 Thermodynamic 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 Thermodynamic.
Skills	Students are able to calculate the internal energy, the enthalpy, the kinetic and the potential energy as well as work and heat for simple change of states and to use this calculations for the Carnot cycle. They are able to calculate state variables for an ideal and for a real gas from measured thermal state variables.
Personal Competence	
Social Competence	The students are able to discuss in small groups and develop an approach.
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program): Core qualification: Compulsory Bioprocess Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory General Engineering Science (English program): Core qualification: Compulsory Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory Mechanical Engineering: Core qualification: Compulsory Mechatronics: Core qualification: Compulsory Naval Architecture: Core qualification: Compulsory Technomathematics: Specialisation Engineering Science: Elective Compulsory Process Engineering: Core qualification: Compulsory

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

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

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

Module M0757: Biochemistry and Microbiology

Courses

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

Module Responsible	Prof. Rudolf Müller
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
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory Technomathematics: Specialisation 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	Prof. Rudolf Müller
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	Problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Rudolf Müller
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0881: Microbiology	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Kerstin Sahm, Prof. Garabed Antranikian
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	Problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Kerstin Sahm
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

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
Examination	Written exam
Examination duration and scale	60 min (Analysis II) + 60 min (Linear Algebra II)
Assignment for the Following Curricula	General Engineering Science (German program): Core qualification: Compulsory Civil- and Environmental Engineering: Core qualification: Compulsory Bioprocess Engineering: Core qualification: Compulsory Electrical Engineering: Core qualification: Compulsory Energy and Environmental Engineering: 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 Naval Architecture: Core qualification: Compulsory Process Engineering: Core qualification: Compulsory

Course L1025: Analysis II	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	• power series and elementary functions • 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	• R. Ansorge, H. J. Oberle: Mathematik für Ingenieure, Band 1; Verlag Wiley-VCH, Berlin, Weinheim, New York, 2000 • H.J. Oberle, K. Rothe, Th. Sonar: Mathematik für Ingenieure, Band 3: Aufgaben und Lösungen; Verlag Wiley-VCH, Berlin, Weinheim, New York, 2000.

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

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

Course L0915: Linear Algebra II	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Anusch Taraz
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 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
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

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
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0888: Organic Chemistry

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

Module Responsible	Prof. Andreas Liese
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. 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 for given tasks.
Autonomy	Students are able to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
Workload in Hours	Independent Study Time 82, Study Time in Lecture 98
Credit points	6
Examination	Written exam
Examination duration and scale	90 Minuten
Assignment for the Following Curricula	Bioprocess Engineering: Core qualification: Compulsory Energy and Environmental Engineering: 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. Patrick Theato
Language	DE
Cycle	SoSe
Content	The lecture covers basic concepts of organic chemistry. This includes simple carbon compounds, alkanes, alkenes, aromatic compounds, alcohols, phenols, ethers, aldehydes, ketones, carboxylic acids, esters, amines, amides and amino acids. Further, fundamentals of reaction mechanisms will be described. This includes nucleophilic substitution, eliminations, additions and aromatic substitution. Also modern reaction mechanisms will be described.
Literature	gängige einführende Werke zur Organischen Chemie. Z.B. „Organische Chemie“ von K.P.C.Vollhart & N.E.Schore, Wiley VCH

Course L0832: Organic Chemistry	
Typ	Laboratory Course
Hrs/wk	3
CP	2
Workload in Hours	Independent Study Time 18, Study Time in Lecture 42
Lecturer	Prof. Patrick Theato
Language	DE
Cycle	SoSe
Content	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. Günter Ackermann
Admission Requirements	none
Recommended Previous Knowledge	Basics of mathematics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can to draw and explain circuit diagrams for electric and electronic circuits with a small number of components. They can describe the basic function of electric and electronic componentes and can present the corresponding equations. They can demonstrate the use of the standard methods for calculations.
Skills	Students are able to analyse electric and electronic circuits with few components and to calculate selected quantities in the circuits. They apply the ususal methods of the electrical engineering for this.
Personal Competence	
Social Competence	none
Autonomy	Students are able independently to analyse electric and electronic circuits and to calculate selected quantities in the circuits.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Written exam
Examination duration and scale	135 Minuten
Assignment for the Following Curricula	Bioprocess Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory Logistics and Mobility: Core qualification: Compulsory Mechanical Engineering: Core qualification: Compulsory Naval Architecture: Core qualification: Compulsory Process Engineering: Core qualification: Compulsory

Course L0290: Basics of Electrical Engineering

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Günter Ackermann
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. Günter Ackermann
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 M0688: Technical Thermodynamics II

Courses

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

Module Responsible	Prof. Gerhard Schmitz
Admission Requirements	none
Recommended Previous Knowledge	Elementary knowledge in Mathematics, Mechanics and Technical Thermodynamics I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are familiar with different cycle processes like Joule, Otto, Diesel, Stirling, Seiliger and Clausius-Rankine. They are able to derive energetic and exergetic efficiencies and know the influence different factors. They know the difference between anti clockwise and clockwise cycles (heat-power cycle, cooling cycle). They have increased knowledge of steam cycles and are able to draw the different cycles in Thermodynamics related diagrams. They know the laws of gas mixtures, especially of humid air processes and are able to perform simple combustion calculations. They are provided with basic knowledge in gas dynamics and know the definition of the speed of sound and know about a Laval nozzle.
Skills	Students are able to use thermodynamic laws for the design of technical processes. Especially they are able to formulate energy, exergy- and entropy balances and by this to optimise technical processes. They are able to perform simple safety calculations in regard to an outflowing gas from a tank. They are able to transform a verbal formulated message into an abstract formal procedure.
Personal Competence	
Social Competence	The students are able to discuss in small groups and develop an approach.
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program): Core qualification: Compulsory General Engineering Science (German program, 7 semester): Core qualification: Compulsory Bioprocess Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory General Engineering Science (English program): Core qualification: Compulsory General Engineering Science (English program, 7 semester): Core qualification: Compulsory Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory Mechanical Engineering: Core qualification: Compulsory Mechatronics: Core qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Technomathematics: Core qualification: Elective Compulsory Technomathematics: Core qualification: 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. Gerhard Schmitz
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. Gerhard Schmitz
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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

Module M0853: Mathematics III

Courses

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

Module Responsible	Prof. Anusch Taraz
Admission Requirements	none
Recommended Previous Knowledge	Mathematics I + II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in the area of analysis and differential equations. They are able to explain them using appropriate examples. • 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
Examination	Written exam
Examination duration and scale	60 min (Analysis III) + 60 min (Differential Equations 1)
Assignment for the Following Curricula	General Engineering Science (German program): Core qualification: Compulsory General Engineering Science (German program, 7 semester): Core qualification: Compulsory Civil- and Environmental Engineering: Core qualification: Compulsory Bioprocess Engineering: Core qualification: Compulsory Computer Science: Core qualification: Compulsory Electrical Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory General Engineering Science (English program): Core qualification: Compulsory General Engineering Science (English program, 7 semester): Core qualification: Compulsory Computational Science and Engineering: Core qualification: Compulsory Mechanical Engineering: Core qualification: Compulsory Mechatronics: Core qualification: Compulsory Naval Architecture: Core qualification: Compulsory Process Engineering: Core qualification: Compulsory

Course L1028: Analysis III	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	WiSe
Content	Main features of differential and integrational calculus of several variables • 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 M0877: Fundamentals in Molecular Biology

Courses

Title	Typ	Hrs/wk	CP
Genetics and Molecular Biology (L0889)	Problem-based Learning	1	1
Genetics and Molecular Biology (L0886)	Lecture	2	2
Lab Course in Microbiology and Biochemistry (L0890)	Laboratory Course	3	3

Module Responsible	Dr. Christian Schäfers
Admission Requirements	none
Recommended Previous Knowledge	Lecture Biochemistry Lecture Microbiology
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successfully finishing this module students are able • to give an overview of the basic genetic processes in the cell • to explain basic molecularbiological methods • to give an overview of -omics strategies • to explain genetic differences between pro- and eukaryotes
Skills	Students are able to • consider safety measurements when working in the laboratory • work sterile • cultivate microorganisms aerobically • measure enzyme activity • identify microorganisms based and physiological assays and 16S rRNA encoding gene sequences • apply core knowledge of the lectures "Biochemistry" and "Microbiology" in laboratory experiments
Personal Competence	
Social Competence	Students are able to • conduct laboratory experiments in teams • write protocols in teams • develop solutions for given problems • develop and distribute work assignments for given problems • present and reflect their specific knowledge in discussions with fellow students and tutors
Autonomy	Students are able to • search information for a given problem by themselves • prepare summaries of their search results for the team
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Examination	Written exam
Examination duration and scale	45 min
Assignment for the Following Curricula	Bioprocess Engineering: Core qualification: Compulsory

Course L0889: Genetics and Molecular Biology

Typ	Problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Christian Schäfers
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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

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

Module M0536: Fundamentals of Fluid Mechanics

Courses

Title	Typ	Hrs/wk	CP
Fundamentals of Fluid Mechanics (L0091)	Lecture	2	4
Fluid Mechanics for Process Engineering (L0092)	Recitation Section (large)	2	2

Module Responsible	Prof. Michael Schlüter
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics I+II+III • 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 124, Study Time in Lecture 56
Credit points	6
Examination	Written exam
Examination duration and scale	3 hours
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core qualification: Compulsory

Course L0091: Fundamentals of Fluid Mechanics	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	SoSe
Content	• fluid properties • 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 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 M0544: Phase Equilibria Thermodynamics

Courses

Title	Typ	Hrs/wk	CP
Thermodynamics III (L0114)	Lecture	2	2
Thermodynamics III (L0140)	Recitation Section (small)	1	2
Thermodynamics III (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
Examination	Written exam
Examination duration and scale	120 minutes; theoretical questions and calculations
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Process Engineering: Core qualification: Compulsory

Course L0114: Thermodynamics III	
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. 3rd ed. Prentice Hall, 1997.J.P. O´Connell, J.M. Haile: Thermodynamics. Cambridge University Press, 2005.

Course L0140: Thermodynamics III	
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: Thermodynamics III	
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 M0891: Informatics for Process Engineers

Courses

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

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

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

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

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

Module M0829: Foundations of Management

Courses

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

Module Responsible	Prof. Christoph Ihl
Admission Requirements	None
Recommended Previous Knowledge	Basic Knowledge of Mathematics and Business
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After taking this module, students know the important basics of many different areas in Business and Management, from Planning and Organisation to Marketing and Innovation, and also to Investment and Controlling. In particular they are able to • explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management • explain the most important aspects of and goals in Management and name the most important aspects of entreprneurial projects • describe and explain basic business functions as production, procurement and sourcing, supply chain management, organization and human ressource management, information management, innovation management and marketing • explain the relevance of planning and decision making in Business, esp. in situations under multiple objectives and uncertainty, and explain some basic methods from mathematical Finance • state basics from accounting and costing and selected controlling methods.
Skills	Students are able to analyse business units with respect to different criteria (organization, objectives, strategies etc.) and to carry out an Entrepreneurship project in a team. In particular, they are able to • analyse Management goals and structure them appropriately • analyse organisational and staff structures of companies • apply methods for decision making under multiple objectives, under uncertainty and under risk • analyse production and procurement systems and Business information systems • analyse and apply basic methods of marketing • select and apply basic methods from mathematical finance to predefined problems • apply basic methods from accounting, costing and controlling to predefined problems
Personal Competence	
Social Competence	Students are able to • work successfully in a team of students • to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project • to communicate appropriately and • to cooperate respectfully with their fellow students.
Autonomy	Students are able to • work in a team and to organize the team themselves • to write a report on their project.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Examination	Written exam
Examination duration and scale	90 Minuten
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory General Engineering Science (German program): Specialisation Computer Science: Compulsory General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory General Engineering Science (German program): Specialisation Civil- and Enviromental Engeneering: Compulsory General Engineering Science (German program): Specialisation Mechanical Engineering: Compulsory General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program): Specialisation Naval Architecture: Compulsory General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process 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 Computer Science: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental 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 Biomechanics: 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 Materials in Engineering Sciences: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory 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 Energy Systems: Compulsory Civil- and Environmental Engineering: Core qualification: Compulsory Bioprocess Engineering: Core qualification: Compulsory Computer Science: Core qualification: Compulsory Electrical Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Civil- and Enviromental Engeneering: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory General Engineering Science (English program): Specialisation Computer Science: Compulsory General Engineering Science (English program): Specialisation Mechanical Engineering: Compulsory General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program): Specialisation Naval Architecture: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Civil Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory Computational Science and Engineering: Core qualification: Compulsory Logistics and Mobility: Core qualification: Compulsory Mechanical Engineering: Core qualification: Compulsory Mechatronics: Core qualification: Compulsory Naval Architecture: Core qualification: Compulsory Technomathematics: Core qualification: Compulsory Process Engineering: Core qualification: Compulsory

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

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

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)	Laboratory Course	2	2

Module Responsible	Prof. Andreas Liese
Admission Requirements	none
Recommended Previous Knowledge	none, 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
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: 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, Prof. An-Ping Zeng
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, Prof. An-Ping Zeng
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	Laboratory Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
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

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

	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Technomathematics: Core qualification: 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 M0546: Thermal Separation Processes

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Thermal Separation Processes (L0118)	Lecture	2	2
Thermal Separation Processes (L0119)	Recitation Section (small)	2	2
Thermal Separation Processes (L0141)	Recitation Section (large)	1	1
Separation Processes (L1159)	Laboratory Course	1	1

Module Responsible	Prof. Irina Smirnova
Admission Requirements	None
Recommended Previous Knowledge	Recommended requirements: Thermodynamics III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• The students can distinguish and describe different types of separation processes such as distillation, extraction, and adsorption • 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
Examination	Written exam
Examination duration and scale	120 minutes; theoretical questions and calculations
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: 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	Laboratory Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Course work	Compulsory attendence of the colloquia of all experiments and compulsory report.
Lecturer	Prof. Irina Smirnova
Language	DE/EN
Cycle	SoSe
Content	The students work on eight different experiments in this practical course. For every one of the eight experiments, a colloquium takes place in which the students explain and discuss the theoretical background and its translation into practice with staff and fellow students. 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 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
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program): Core qualification: Compulsory General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process 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 Biomechanics: 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 Materials in Engineering Sciences: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory 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 Energy Systems: Compulsory Bioprocess Engineering: Core qualification: Compulsory Computer Science: Specialisation Computational Mathematics: Elective Compulsory Electrical Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory General Engineering Science (English program): Core qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory

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

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

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)	Laboratory 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
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: 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	Laboratory Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Raimund Horn, Dr. Achim Bartsch
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 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. An-Ping Zeng
Admission Requirements	none
Recommended Previous Knowledge	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 to • describe and explain different kinetic approaches for growth and substrate-uptake • identification of scientific problems with concrete industrial use (cultivation of microorganisms and mammalian cells) • describe and explain important downstreaming steps for proteins and their application as well as basic immobilization methods
Skills	After successful completion of this module, students should be able to - to identifiy 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 microaerobically) - 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 - Establish material flow balance equations and solve them to determine the kinetic parameters of different approaches and to calculate immobilization and activity yields , - to select process control strategies (batch , fed-batch , continuity) 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 aquire 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
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Technomathematics: Core qualification: 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. An-Ping Zeng, Prof. Andreas Liese, Dr. Wael Sabra
Language	DE
Cycle	WiSe
Content	• Introduction: state-of-the-art and development trends of microbial and biocatalytic bioprocesses, introduction to the lecture • Enzymatic process I: reactor types and criteria for industrial biotransformations (Prof. Liese) • Enzymatic process II (Prof. Liese) • Immobilization technologies: basic methods for isoltaed enzymes/ cells (Prof. Liese) • Anaerobic fermentation processes (Prof. Zeng) • Microaerobic bioprocesses: kinetics, energetics, optimal O2-supply and scale-up (Prof. Zeng) • Fedbatch process and cultivation with high cell density (Prof. Zeng) • Downstream processing of protein bioproduction: basics of chromatography, membrane filtration (Prof. Liese) • Cell culture technology and continuous culture: basics, kinetics, media, reactors (Prof. Zeng) • Problem-based learning with selected bioprocesses (Prof. Liese, Prof. Zeng)
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 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. An-Ping Zeng, Prof. Andreas Liese
Language	DE
Cycle	WiSe
Content	• Introduction: state-of-the-art and development trends of microbial and biocatalytic bioprocesses, introduction to the lecture • Enzymatic process I: reactor types and criteria for industrial biotransformations (Prof. Liese) • Enzymatic process II (Prof. Liese) • Immobilization technologies: basic methods for isoltaed enzymes/ cells (Prof. Liese) • Anaerobic fermentation processes (Prof. Zeng) • Microaerobic bioprocesses: kinetics, energetics, optimal O2-supply and scale-up (Prof. Zeng) • Fedbatch process and cultivation with high cell density (Prof. Zeng) • Downstream processing of protein bioproduction: basics of chromatography, membrane filtration (Prof. Liese) • Cell culture technology and continuous culture: basics, kinetics, media, reactors (Prof. Zeng) • Problem-based learning with selected bioprocesses (Prof. Liese, Prof. Zeng) 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	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 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	2
Process and Plant Engineering I (L0096)	Recitation Section (large)	1	2
Process and Plant Engineering I (L1214)	Recitation Section (small)	1	2

Module Responsible	Prof. Georg Fieg
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
Examination	Written exam
Examination duration and scale	120 Min. lectures notes and books
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Elective Compulsory Bioprocess Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Elective Compulsory Process Engineering: Core qualification: Compulsory

Course L0095: Process and Plant Engineering I

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Course work	none
Lecturer	Prof. Georg Fieg
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	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Course work	none
Lecturer	Prof. Georg Fieg
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	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Course work	none
Lecturer	Prof. Georg Fieg
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0670: Particle Technology and Solids Process Engineering

Courses

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

Module Responsible	Prof. Stefan Heinrich
Admission Requirements	None
Recommended Previous Knowledge	keine
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of the module students are able to • 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
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: 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	Laboratory Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Stefan Heinrich
Language	DE
Cycle	SoSe
Content	• Sieving • 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.

Thesis

Module M-001: Bachelor Thesis

Courses			
Title	Typ	Hrs/wk	CP

Module Responsible	Professoren der TUHH
Admission Requirements	• According to General Regulations §24 (1): 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
Examination	according to Subject Specific Regulations
Examination duration and scale	laut FSPO
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 Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy and Environmental Engineering: Thesis: Compulsory General Engineering Science (English program): Thesis: Compulsory General Engineering Science (English program, 7 semester): Thesis: Compulsory Computational Science and Engineering: Thesis: Compulsory Logistics and Mobility: Thesis: Compulsory Mechanical Engineering: Thesis: Compulsory Mechatronics: Thesis: Compulsory Naval Architecture: Thesis: Compulsory Technomathematics: Thesis: Compulsory xx: Thesis: Compulsory Process Engineering: Thesis: Compulsory