TUM Campus Straubing for Biotechnology and Sustainability (TUMCS)
Technische Universität München

Module Catalog

B.Sc. Chemical Biotechnology

TUM Campus Straubing for Biotechnology and Sustainability (TUMCS)
Technische Universität München

www.tum.de/
www.cs.tum.de/

Module Catalog: General Information and Notes to the Reader

What is the module catalog?
One of the central components of the Bologna Process consists in the modularization of university curricula, that is, the transition of universities away from earlier seminar/lecture systems to a modular system in which thematically-related courses are bundled together into blocks, or modules.
This module catalog contains descriptions of all modules offered in the course of study.
Serving the goal of transparency in higher education, it provides students, potential students and other internal and external parties with information on the content of individual modules, the goals of academic qualification targeted in each module, as well as their qualitative and quantitative requirements.

Notes to the reader:

Updated Information
An updated module catalog reflecting the current status of module contents and requirements is published every semester. The date on which the module catalog was generated in TUMonline is printed in the footer.

Non-binding Information
Module descriptions serve to increase transparency and improve student orientation with respect to course offerings. They are not legally-binding. Individual modifications of described contents may occur in praxis.
Legally-binding information on all questions concerning the study program and examinations can be found in the subject-specific academic and examination regulations (FPSO) of individual programs, as well as in the general academic and examination regulations of TUM (APSO).

Elective modules
Please note that generally not all elective modules offered within the study program are listed in the module catalog.

Index of module handbook descriptions (SPO tree)

Alphabetical index can be found on page 133

Module Description

CS0175: Advanced Mathematics 1 | Höhere Mathematik 1

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Learning outcomes are verified in a written exam. The exam consists of assignments in which the students are to demonstrate that they understand the mathematical methods conveyed as part of the module and are able to apply them to specific examples. Exam duration: 90 minutes

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Knowledge in mathematics corresponding to basic knowledge of A-level students.

Content:
Selected topics from one-dimensional analysis and linear algebra that are required in engineering. In particular: real and complex numbers, mathematical induction, sequences and series, limits, functions, continuity, single variable calculus, systems of linear equations, matrices, determinants. The methods are presented during the lecture and are applied to specific examples related to sustainability in the exercise classes.

Intended Learning Outcomes:
After completion of the module, students understand the fundamental concepts and essential methods from one-dimensional analysis and linear algebra. They are able to apply mathematical arguments in these fields independently. Moreover, they can apply the central proof techniques and concepts and comprehend their mathematical background.

Teaching and Learning Methods:
Lecture using digital presentation and/or blackboard to convey contents and methods. In addtion, concrete examples are discussed in the exercise classes through independent work and group

work in order to practice the adequate expression and independent application of mathematical arguments.

Media:
Blackboard, slides, exercise sheets

Reading List:
K. Königsberger, Analysis 1, 6. Auflage, Springer 2004.
C. Karpfinger, Höhere Mathematik in Rezepten, 3. Auflage, Springer Spektrum 2017

Responsible for Module:
Thielen, Clemens; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Höhere Mathematik 1 (Übung) (Übung, 2 SWS)
Thielen C [L], Meier F, Thielen C, Wittmann A

Höhere Mathematik 1 (Vorlesung) (Vorlesung, 2 SWS)
Thielen C [L], Thielen C
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1600: Physics | Physik [Phys]

Version of module description: Gültig ab summerterm 2024

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 60	**Contact Hours:** 90

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Achievement of desired learning objectives shall be verified in a written final exam (90 minutes). There, the students demonstrate that they know and understand the physical concepts imparted during the lecture. By solving specific physical problems the students demonstrate that they are able to also use acquired concepts in a solution-oriented way in simple cases.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Good A-level knowledge of mathematics, prep courses mathematics/ physics (usually offered shortly before semester start)

Content:
The module of physics provides an introduction into classical physics. The module introduces into the math-based approach of physics for nature description. The lecture includes the basics of mechanics, thermal engineering, electricity and optics.

Intended Learning Outcomes:
The module serves to acquire physical basics. The students know the basic concepts of mechanics, thermal engineering, electricity and optics. Based on examples treated during the lecture and deepening during the exercise the students learn how to use these concepts to solve simple physical problems. So a solid basis will be created to understand the following course content (e.g. Thermodynamics, energy technology) and to use acquired knowledge in an advanced way there.

Teaching and Learning Methods:
Lecture (oral presentation by teaching staff including filling in the gap text lecture notes, writing on the board, PP media, demonstration experiments), exercise (deepening of course contents with tutors) with work in small groups.

Media:
Gap text lecture notes, writing on the board, presentations, demonstration experiments

Reading List:
"U. Harten: Physik, Einführung für Ingenieure und Naturwissenschaftler (Physics, Introduction for Engineers and Scientists), 4th edition 2009, Springer
Paul A. Tipler: Physik (Physics), Spektrum (Panoply), Akademischer Verlag Heidelberg, Berlin, Oxford"

Responsible for Module:
Kainz, Josef; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Physics (Lecture) (Vorlesung, 2 SWS)
Kainz J [L], Kainz J

Physics (Exercise) (Übung, 2 SWS)
Kainz J [L], Kainz J, Sun J
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1922: General Chemistry | Allgemeine Chemie [Chem]

Version of module description: Gültig ab winterterm 2021/22

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The performance test will be in the form of a written examination rendered. The students should demonstrate in the exam the understanding of the structure of chemical compounds and their typical reactions and chemical conversions. It will also be tested the ability to formulate reaction equations, calculate reaction kinetic and thermodynamic parameters, as well as to transfer the acquired knowledge about the structure and reaction behavior of chemical substance groups to new chemical questions. No auxiliary means are allowed in the exam. 90 min examination time

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of chemistry, mathematics and physics, which correspond to the basic course knowledge of the gymnasiale upper school

Content:
General principles of inorganic and physical chemistry: Atomic and molecular construction, structure of compounds, acid / base equilibria, redox reactions, thermodynamics, reaction kinetics and catalysis, fundaments on electrochemistry, selected reactions of inorganic chemistry

Intended Learning Outcomes:
The students will know and understand the basic principles of chemical reactions and will be able to formulate correct reaction equations and simple reaction kinetic and thermodynamic calculations. Moreover, they will be able to apply the knowledge acquired with model reactions about chemical transformations of chemical substances and substance groups to answer new chemical questions. The successful participation in the module will enable the students to participate in the module of basic organic chemistry.

Teaching and Learning Methods:
Lectures and corresponding exercises with self-analysis and workup of specific case studies. In relation to the teaching content exercise sheets are disbursed on which the students work in self-study before the tutorials. The solution and discussion takes place in the tutorials. At the postprocessing of the lecture exspecially while the exercises are solved the students keep themselves intensive busy with the teaching contents of the lecture and reach in this way a understanding of the structure and reaction behavior of chemical substance groups and practise the formulation of reaction equations.

Media:
Blackboard, presentation (using script), exercises.

Reading List:
1) Theodore L., H. Eugene LeMay, Bruce E. Bursten, Chemie Studieren Kompakt, 10. aktualisierte Auflage, Pearson Verlag, München;
2) Charles E. Mortimer, Ulrich Müller, Chemie, 10., überarbeite Auflage, Thieme Verlag, Stuttgart

Responsible for Module:
Riepl, Herbert; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Allgemeine und anorganische Chemie (Übung) (Übung, 2 SWS)
Riepl H [L], Riepl H

Allgemeine und anorganische Chemie / Angleichung Chemie (Vorlesung) (Vorlesung, 2 SWS)
Riepl H [L], Riepl H
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1923: Physical Chemistry | Physikalische Chemie [PhysChem]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning results are going to be proved in form of a written test (120 min). The students solve physical/chemical arithmetic problems and answer questions for definitions or physical/chemical relations. They prove that they have understood the basic relations of physical chemistry that are highlighted within the scope of the module and can use the systems of equations. Calculators are allowed additives. Other additives can be permitted by the lecturer as needed.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
A-level student knowledge of mathematics (especially differentiation and integration) and physics

Content:
Basics of chemical thermodynamics: laws of thermodynamics, forms of energy (U, H, G, S), relations of formulas; chemical equilibrium and chemical reactions; properties of gases; phase transition of pure substances and multiphase systems; two component systems; selected boundary surface phenomena; basics of reaction kinetics

Intended Learning Outcomes:
After successful completion of the module the students know the laws of thermodynamics; they are able to make calculations concerning U, H, S and G; they understand phase diagrams of one and two component systems, can create charts and calculate the condition of equilibrium of simple systems; they can calculate with partial molar quantities in multi component systems; they can use ideal and real gas equations; they are able to form and solve equations related to the kinetics of chemical reactions and to determine the order of reactions;

Teaching and Learning Methods:
Teaching methods: in the lecture the teaching content is communicated by a talk of the lecturer, supported by PowerPoint and sketches on the blackboard in which the latter form is chosen to derivate complex relations. To a limited extent this can be completed for selected topics by self-study of the textbook by the students. In relation to the teaching content exercise sheets are disbursed on which the students work in self-study before the tutorials. The solution and discussion takes place in the tutorials. Learning methods: at the postprocessing of the lecture especially while the exercises are solved the students keep themselves intensive busy with the teaching contents of the lecture and reach in this way a understanding of the physical-chemical relations and practise the usage of the systems of equations.

Media:
PowerPoint, whiteboard, exercise sheets, textbook, optional: script

Reading List:
Lehrbuch: P.W. Atkins, J. de Paula, Physikalische Chemie, 5. Auflage, Wiley-VCH, 2013

Responsible for Module:
Schieder, Doris; Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1924: Basic Organic Chemistry | Grundlagen Organische Chemie [OrgChem]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The performance test will be in the form of a written examination rendered. The students should demonstrate in the exam the understanding of the structure of organic chemical compounds and their typical reactions and chemical conversions. It will also be tested the ability to formulate reaction equations, as well as to transfer the acquired knowledge about the structure and reaction behavior of organic chemical substance groups to new chemical questions. No auxiliary means are allowed in the exam. 90 min examination time

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Knowledge of chemistry, mathematics and physics, which correspond to the basic course knowledge of the gymnasiale upper school

Content:
General principles of organic chemistry:
Structure of organic compounds, carbon-atom hybridization, important functional groups, nomenclature and structure of organic molecules, selected reactions of organic chemistry for important groups of substances including central natural substances.

Intended Learning Outcomes:
The students will know and understand the basic principles of organic chemical reactions and will be able to formulate correct organic reactions. Moreover, they will be able to apply the knowledge acquired with model reactions about chemical transformations of organic chemical substances and substance groups to answer new chemical questions.The successful participation in the module

will also enable the students to participate in the practical course and the module advanced organic chemistry.

Teaching and Learning Methods:
Lectures and corresponding exercises with self analysis and workup of specific case studies. In relation to the teaching content exercise sheets are disbursed on which the students work in self-study before the tutorials. The solution and discussion takes place in the tutorials. At the postprocessing of the lecture exspecially while the exercises are solved the students keep themselves intensive busy with the teaching contents of the lecture and reach in this way a understanding of the structure and reaction behavior of organic chemical substance groups and practise the formulation of reaction equations.

Media:
Blackboard, presentation (using script), exercises

Reading List:
K.P.C. Vollhardt, N.E. Schore, Organische Chemie, Verlag VCH Weinheim

Responsible for Module:
Prof. Nicolas Plumeré Dr. Alaa Alsheikh Oughli

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Compulsory Courses Area Chemistry | Pflichtmodule Bereich Chemie

Module Description

WZ1925: Practical Course General Chemistry | Praktikum Allgemeine Chemie [Chem]

Version of module description: Gültig ab winterterm 2022/23

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Perfomance is going to be effected by a protocol in the form of the lab journal. For each lab experiment, two handwritten pages containing experimental procedure and analysis should be prepared. Therein students should prove their understanding of the structure of chemical compounds and aggregation states. In addition, they should show that they understand chemical reactions and their thermodynamic and kinetic aspects. Furthermore, the students should show that they are able to use lab instruments and equipment correctly for chemical experiments.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Knowledge of chemistry, mathematics and physics, which correspond to the basic course knowledge of the gymnasiale upper school

Content:
General principles of inorganic and physical chemistry and experimental essays: Structure of compounds, acid / base equilibria, redox reactions, thermodynamics, reaction kinetics, selected reactions of inorganic chemistry.

Intended Learning Outcomes:
The students will know and understand chemical structures, aggregation states of compounds and the basic principles of chemical reactions. The students will get familiar with the practical work in chemical laboratories. They will be able to perform and formulate correctly chemical reactions, and experimentally determine thermodynamic and kinetic aspects of chemical reactions. The

successful participation in the module will enable the students to participate in the module of basic organic chemistry

Teaching and Learning Methods:
Laboratory experiments and equipment.

Media:
Laboratory equipment.

Reading List:
1) Practical Labor Script; 2) Theodore L., H. Eugene LeMay, Bruce E. Bursten, Chemie Studieren Kompakt, 10. aktualisierte Auflage, Pearson Verlag, München;

Responsible for Module:
Prof. Rubén Costa

Courses (Type of course, Weekly hours per semester), Instructor:
Labor-Praktikum Allgemeine und anorganische Chemie (Praktikum, 5 SWS)
Costa Riquelme R [L], Asin Vicente A, Atoini Y, Englberger H, Jaschik L, Maidl M, Mauz A, Nieddu M, Schieder D, Wolf P
For further information in this module, please click campus.tum.de or here.

Module Description

CS0215: Practical Course Organic Chemistry | Praktikum Organische Chemie [OCP]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Leistung wird in Form eines Protokolls in Form des Laborjournals erbracht. Pro Experiment sollen handschriftlich etwa zwei Seiten, welche Versuchsdurchführung und Auswertungen enthalten, angefertigt werden. Zusätzlich soll zu einem bis zwei ausgewählten Versuchen ein etwa dreiseitiges Protokoll am PC erstellt werden. Dafür müssen die experimentell erhaltenen Daten analysiert werden.
Bei geeigneter Deckung mit den in Musterversuchen erhaltenen Werten und einer ausreichenden Analyse der erhaltenen Werte sowie einer korrekten Beschreibung des Versuchsaufbaus gilt das Praktikum als bestanden.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Grundlagen organische Chemie, anorganische Chemie

Content:
Rückflusskochen, Kristallisieren, Destillieren, Abnutschen, Ausschütteln mit nicht mischbaren organischen Lösungsmitteln, Dünnschichtchromatographie, Säulenchromatographie

Intended Learning Outcomes:
Die Studierenden haben praktische Fähigkeiten zur Durchführung organisch chemischer Reaktionen erworben. Anhand einfacher Reaktionen wurden die typischen Handgriffe organisch-chemischen Arbeitens erlernt. Die Studenten können nach Abschluss des Praktikums einen Versuch korrekt vorbereiten und aufbauen, durchführen, protokollieren, das erhaltene Ergebnis analysieren, sowie mögliche Ursachen von Fehlwerten erkennen.

Teaching and Learning Methods:
Durch eigenes Experimentieren der Studierenden unter Anleitung werden Handhabung von Chemikalien und Geräten eingeübt, dadurch werden manuelle Fähigkeiten und experimentelles Geschick erworben. Es werden ca. 10 Versuche durchgeführt.

Media:
Praktikumslabor

Reading List:
H.G. Becker, Organikum, 21. Aufl., Wiley VCH

Responsible for Module:
Prof. Nicolas Plumeré

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1927: Instrumental Analysis and Spectroscopy | Instrumentelle Analytik und Spektroskopie

Version of module description: Gültig ab winterterm 2021/22

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 8	**Total Hours:** 240	**Self-study Hours:** 135	**Contact Hours:** 105

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination consists of a written exam with 90min duration and serves to check the knowledge of the theoretical basics of all treated analytical methods, since only an excerpt of these methods is applied in the seminar part.

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
In the module the basics of instrumental analysis are communicated. Thereby particular physicochemical characterization methods, basic principles of measurement and the setting of analysis instruments are disscussed in detail. In detail are these: optic/electricl/magnetic measuremnts, adsorption/desorption as basis for chromatopraphic techniques, adsorption/ desorption related to vibrational spectroscopy and UV/Vis spectroscopy, nuclear resonance spectroscopy, mass determination and spectrometry, scatter methods, atomic spectroscopy and gas and high performance liquid chromatography. The handling of the received measuring results is explained by case studies.

Intended Learning Outcomes:
After visiting the required modul the students are able to select corresponding physicochemical analysis methods for underlying practical problems and to use these methods as needed. On the basis of the gained knowledge the students can analyse the obtained measuring results in a competent way.

Teaching and Learning Methods:
The theoretical basics of the experiments conducted in the practical course will be delivered in the lecture part via ppt-presentations, movies and white board. In the practical course, the students will self-reliantly perform, document and analyse their experiments.

Media:
presentation, script, cases and solutions lab and equipment

Reading List:
script, sample solutions for the exercises

Responsible for Module:
Zollfrank, Cordt; Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Instrumentelle Analytik und Spektroskopie (Vorlesung) (Vorlesung, 3 SWS)
Rühmann B [L], Riepl H, Rühmann B, Urmann C, Zieleniewska A

Instrumentelle Analytik und Spektroskopie (Seminar) (Übung, 4 SWS)
Rühmann B [L], Riepl H, Rühmann B, Urmann C, Zieleniewska A
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1928: Advanced Organic Chemistry | Organische Chemie für Fortgeschrittene [AOC]

Version of module description: Gültig ab winterterm 2017/18

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students are able to demonstrate thier understanding of chemical reactions concerned in this course in a written exam with formula equations (90 min). The students show their understanding of different classes of natural compounds in formula equations.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
module basic organic chemistry

Content:
Fossil oil and natural gas as primary source, crack- und steam reforming reactions, technical olefin chemistry, technical aromatic chemistry, polyolefins, nitrogen containing organic intermediates, carboxylic acids and oxygen containing intermediates in polyester production. Chemistry of carbonyl compounds and carbohydrates.

Intended Learning Outcomes:
After successfully managing this module, the students are able to understand the chemical reactions of our fossil based chemical production. They can present product trees, based on side products or associated products. By this knowledge they can identify intermediates up to the ready polymer product. The students can apply typical reactions of different organic compounds.

Teaching and Learning Methods:
Lecture by academic teaching personnel with PP-presentations, books, printed matter and others. Visit of production plants of nearby chemical industry to see typical industrial scale of reactions. In relation to the teaching content exercise sheets are disbursed on which the students work

in self-study before the tutorials. The solution and discussion takes place in the tutorials. At the postprocessing of the lecture especially while the exercises are solved the students keep themselves intensive busy with the teaching contents of the lecture and reach in this way a understanding of the chemical reactions of our fossil based chemical production and practise the presentation of product trees.

Media:
Powerpoint presentations, whiteboard, printed text of teaching

Reading List:
K. Weissermel, H.J.Arpe, Industrial Organic Chemistry, 4. Auflage, VCH Weinheim

Responsible for Module:
Riepl, Herbert; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Compulsory Courses Area Molecular Biology | Pflichtmodule Bereich Molekulare Biologie

Module Description

WZ1929: Cell Biology and Microbiology | Zell- und Mikrobiologie [MiBi]

Version of module description: Gültig ab summerterm 2023

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning results are proved in a written test in which the students are to call up and remember important principles of biology without using additives. In addition the students prove that they are able to recognize and solve a problem in a certain time by answering the comprehension questions on covered basic cell and microbiology processes. Answering questions requires mainly the use of own formulations thereby the correct recall of important technical terms is additionally reviewed. During the examination the tasks are set in both languages and the processing of the examination tasks can take place either in German or English. Exam duration: 90 minutes

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
Basics of cell biology (cellular structure (cell wall, plasma membrane, endomembrane system, nucleus), differences between prokaryotic and eukaryotic organisms, theoretical basics of microscopy, transport processes, genetic flow of informations and basics of molecular genetics (e.g. DNA structure, transcription, translation, DNA duplication), basics of biological taxonomy using the example of selected production organisms (e.g. E.coli, S.cerevisiae, algae, fungi), usage of microorgamisms in industrial biotechnolgy (e.g. ethanol fermentation, ABE fermentation, protein synthesis)

Intended Learning Outcomes:
After having participated in the module units the students possess basic knowledge about the structure and function of biomolecules. They know important elements of pro- and eukaryotic cells and can differentiate between these life forms. They know the basics of the genetic flow of informations and of the most important metabolic pathways and can grade bacteria, fungi and plants to higher-ranking systematic groups. After completion of the module the participants know different microorganisms, can describe their properties and understand basic cellular processes. Furthermore, the students can reflect biological terms, define processes and are able to use their knowledge to solve problems. They understand basic ecological challeges and prerequisits of sustainable development.

Teaching and Learning Methods:
The teaching contents are imparted by a talk of the lecturer, supported by PowerPoint and blackboard sketches.

Media:
PowerPoint, blackboard work

Reading List:
"Brock Mikrobiologie" von Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley, David A. Stahl, Pearson, 15. Auflage (2020)
"Campbell Biologie"" von Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece, Pearson, 11. Auflage (2019)

Responsible for Module:
apl. Prof. Erich Glawischnig

Courses (Type of course, Weekly hours per semester), Instructor:
Zell- und Mikrobiologie (Vorlesung, 3 SWS)
Glawischnig E [L], Glawischnig E
For further information in this module, please click campus.tum.de or here.

Module Description

CS0216: Practical Course Microbiology | Praktikum Mikrobiologie

Version of module description: Gültig ab summerterm 2023

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The performance is effected by written protocols of the executed laboratory experiments (About 7 experiments and
for each experiment about 4 pages of protocol). With these protocols the students prove that they are able to understand the theoretical background of the experiments, to report their experimental procedure and to evaluate their results. Furthermore, they should show that they can discuss deviations of the expected results and possible reasons. Assessment of the course as passed/ failed. The course is only passed if the protocol listed above meets the criteria of completeness, correctness and comprehensibility/clarity each to more than 50%, whereby feedback is given on a first draft.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Successful completion of the module Cell and Microbiology (CS0256) or equivalent.

Content:
Microscopy, methods of colony isolation, colony count, differentiation of bacteria, isolation of microorganisms, identification methods for microorganisms, growth behaviour of microorganisms

Intended Learning Outcomes:
After module participation the students are familiar with the execution of experiments in microbiological labs and able to use the mediated microbiological working techniques at least in main features. They handle aseptic techniques and can identify microorganisms. In addition, they possess a deeper understanding of the theories which underlie the experiments, including the ecological significance of microbial metabolism. Furthermore, the students can report laboratory

experiments in a correct way and evaluate and analyse them by means of the theoretical backgrounds under guidance.

Teaching and Learning Methods:
Laboratory experiments in small groups (approx. 14 experiments) under guidance with previous introduction of the theory related to the particular experiments (lecture) as well as analysis of the results by experiment reports. Aspects related to safety issues in the laboratory are also covered in the lectures.

Media:
Practical course script

Reading List:
Practical course script

Responsible for Module:
Erich Glawischnig

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0210: Bioinformatics | Bioinformatik

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Learning outcomes shall be verified in a written test (90 minutes). Knowledge questions check the treated methods, algorithms and concepts in the field of bioinformatics and computational biology.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
CS0001 Foundations of Programming, CS0130 Grundlagen Biologie

Content:
Selected bioinformatic methods required for analyzing biological and bio-chemical data, especially from the area of biological databases (e.g. NCBI, Swissprot), algorithms for sequence alignments (e.g. Needleman-Wunsch, Smith-Waterman, ClustalW, BLAST) as well as methods for phylogenetic analysis. Methods shall be presented during the lecture. Within the scope of the exercise, their application shall be practiced based on specific case studies related to biotechnology and sustainability.

Intended Learning Outcomes:
The students know the most important bioinformatic methods and databases (e.g. NCBI, Swissprot, Needleman-Wunsch, Smith-Waterman, ClustalW, BLAST) for the analysis of biological and biochemical data. They will understand these methods and be able to select and perform appropriate bioinformatic procedures for specific case studies and real data, e.g. when working on biotechnology and sustainability projects.

Teaching and Learning Methods:
Lectures to provide the students with all necessary fundamentals of bioinformatics and its algorithms. In the exercises, the students will work on different analysis and programming tasks

and will develop basic Linux skills to conduct own analysis of biological and bio-chemical problems using bioinformatics tools and algorithms.

Media:
Slide presentation, blackboard, lecture and exercise recording, discussion forums in e-learning platforms, Exercise Sheets

Reading List:
Bioinformatik: Grundlagen, Algorithmen, Anwendungen, Rainer Merkl
Bioinformatics and Functional Genomics, Jonathan Pevsner

Responsible for Module:
Prof. Dr. Dominik Grimm

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1931: Biochemistry | Biochemie [BC]

Version of module description: Gültig ab winterterm 2022/23

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning results are proved in form of a written test (90 min exam duration). Based on questions to biochemical metabolic pathways and enzymology the students prove that they know the corresponding technical terms, designations and contents, that they have understand the basic relations and are able to apply their knowledge concerning the reactions taking place within the scope of kinetic and thermodynamic connections. For that purpose concrete computational tasks are assigned.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful participation in the modules "Basic Organic Chemistry", "General Chemistry" and "Cell and Microbiology".

Content:
Enzymology: Within the module the students shall be introduced into basics of enzyme catalysis. In doing so theories relating to the course of enzymatic reactions, special aspects of kinetics and thermodynamics of enzyme-catalysed reactions, inhibition mechanisms as well as possibilities for calculating kinetic parameters shall be treated inter alia. Metabolism: Basic metabolic pathways such as glycolysis, citrate-cycle or gluconeogenesis shall be presented in the lecture. In doing so it is dealt with the general course of reaction cascades, thermodynamic aspects of energy generation as well as mechanisms of modulation of the individual paths.

Intended Learning Outcomes:
After sucessful completion of the module the students are able to describe and explain basic concepts, phenomenons and relations in the field of biochemistry. The students know important properties of proteins,understand the significance of kinetic parameters of enzymatic reactions

and will be able to calculate them and apply to new issues (e.g. inhibition). Furthermore the students will be able to specify in detail basic metabolic pathways of the most important classes of substances, understand the particular steps and regulation systems of the respective paths.

Teaching and Learning Methods:
In the lecture the teaching content is imparted by speech of the lecturer using powerpoint presentations and blackboard sketches. Corresponding to the teaching content exercise sheets are prepared on which the students work in self-study. The solution and discussion of the exercises takes place in the tutorial.

Media:
Presentations, powerpoint, presentation script, exercise sheets

Reading List:
- Voet, D. , Voet, J.G., Biochemistry 4th Edition, Wiley-VCH, 2011;
- Nelson, D.L, Cox, M.M., Lehninger Principles of Biochemistry 5th Edition, WH Freeman, 2008;
- Berg, J.M, Tymoczko, J.L., Stryer, L., Biochemistry 6th Edition, 2006

Responsible for Module:
Dr.-Ing. Ammar Al-Shameri

Courses (Type of course, Weekly hours per semester), Instructor:
Biochemie (Vorlesung) (Vorlesung, 2 SWS)
Al-Shameri A [L], Al-Shameri A

Biochemie (Übung) (Übung, 2 SWS)
Al-Shameri A [L], Schulz M, Siebert D
For further information in this module, please click campus.tum.de or here.

Module Description

CS0218: Practical Course Biochemistry | Praktikum Biochemie [Pra BC]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 60	**Contact Hours:** 90

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Lernergebnisse werden in einer 30 minütigen mündlichen Prüfung überprüft, in der die Studierenden zeigen, dass sie die theoretischen Hintergründe der Versuche verstanden haben. Darüber hinaus sollen die wichtigsten Ergebnisse der laborpraktischen Versuche berichtet und diskutiert werden und es sollen Fragen zu den durchgeführten Experimenten beantwortet werden können.
Durch die korrekte Durchführung aller Laborexperimente mit korrekter Protokollierung (pro Experiment etwa 5 Seiten Protokoll) weisen die Studierenden zudem nach, dass sie die vermittelten experimentellen Arbeitstechniken anwenden und Laborexperimente ordnungsgemäß dokumentieren können (unbenotete Studienleistung).

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Praktikum Mikrobiologie

Content:
Im Praktikum werden allgemein notwendige Grundlagen für das Arbeiten in biochemischen Laboren, sowie spezielle Methoden zur Trennung und Charakterisierung von Molekülen vermittelt. Darüber hinaus werden grundlegende biochemische Methoden vermittelt, insbesondere die Isolierung von Nukleinsäuren und Proteinen und ihre Analyse mittels Spektroskopie und Gelelektrophorese, sowie die Analyse enzymkatalysierter Reaktionen.

Intended Learning Outcomes:
Nach der Teilnahme an der Modulveranstaltung sind die Studierenden mit dem Ausführen von Experimenten in biochemischen Laboren vertraut und in der Lage, die vermittelten experimentellen Methoden mindestens in den Grundzügen anzuwenden. Sie besitzen zudem ein tieferes

Verständnis der Theorien, die den Experimenten zugrunde liegen. Darüber hinaus können die Studierenden Laborexperimente korrekt protokollieren und anhand der theoretischen Hintergründe unter Anleitung auswerten und analysieren. Sie können ihre Ergebnisse kritisch hinterfragen und auf Plausibilität überprüfen. Die Studierenden verfügen somit über grundlegende praktische Fähigkeiten um in biologisch-chemischen Laboratotien an neuen, biobasierten Synthesen für eine nachhaltige Chemie zu arbeiten.

Teaching and Learning Methods:
Laborexperimente in Kleingruppen unter Anleitung mit vorheriger Einführung in die Theorie zu den einzelnen Experimenten, sowie Auswertung der Ergebnisse in Form von Versuchsprotokollen. In der Übung wird das Dokumentieren und Auswerten der Versuche anhand vorgegebener Daten und Fragestellungen erlernt. Die in der Übung erworbenen Fähigkeiten werden dann bei der Auswertung und Dokumentation der eigenen Experimente angewendet.

Media:
Praktikumsskript, ppt-Präsentationen, Tafelanschrift, Labor, Laborgeräte

Reading List:
Praktikumsskript

Responsible for Module:
Prof. Volker Sieber

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1934: Enzymes and Their Reactions | Enzyme und ihre Reaktionen [EnzReact]

Version of module description: Gültig ab summerterm 2024

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning results are proved in form of a written test (90 min exam duration). Based on questions to biochemical metabolic pathways and enzymology the students prove that they know the corresponding technical terms, designations and contents, that they have understand the basic relations and are able to apply their knowledge concerning the reactions taking place within the scope of kinetic and thermodynamic connections. For that purpose concrete computational tasks are assigned.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful participation in the modules "Basic Organic Chemistry", "General Chemistry" and "Cell and Microbiology".

Content:
Enzymes are higly efficient catalysts of biochemical reactions in living organisms. Thus, they also can make high efficient and selective new catalysts for a future, sustainable green chemistry. With respect to this, the course offers a broad overview of enzyme classes (oxidoreductases, isomerases, hydrolases, lyases, transferases and ligases) and of enzyme-catalysed reactions. Thereby different reaction mechanisms are examined from a chemical point of view and hence the usage of enzymes in simple chemical implementations and technical fields is derived and comprehensively illustrated. The role of complex cofactors (radical forming, redox-active, electron switching, ion stabilisating and so on) is introduced and hence the limitations of enzyme reaction are worked out. With data bases of enzyme reactions and thermodynamic dimensions (e.g. from the theory of group contribution methods) target compounds of enzyme reactions especially in the field of renewables utilization are made accessible.

Intended Learning Outcomes:
After sucessful completion of the module the students know and understand enzyme-catalysed chemical reactions and their meaning for an enhanced sustainibility in chemical synthesis. Based on this knowledge the students are able to design single- and multi-stage enzymatic processes and to evaluate them by means of thermodynamic and kinetic reaction data. Students will thus have the fundamental knowledge for more advanced courses, especially on the bioengineering of enzymes as catalysts for new, sustainable industrial chemical processes.

Teaching and Learning Methods:
In the lecture the teaching content is imparted by speech of the lecturer using powerpoint presentations, blackboard sketches and working on data bases. Corresponding to the teaching content exercise sheets are prepared on which the students work in self-study. The solution and discussion of the exercises takes place in the tutorial.

Media:
Presentations, PowerPonit, lecture script, exercise sheets, computer based work and enzyme reaction data bases

Reading List:
Voet, D. , Voet, J.G., Biochemistry 4th Edition, Wiley-VCH, 2011; Perry A. Frey und Adrian D. Hegeman, Enzymatic Reaction Mechanisms, Oxford Univ Press, 2006; Reinhard Renneberg, Darja Süßbier, Biotechnologie für Einsteiger, 3. Auflage, Spektrum Verlag Heidelberg 2010; A. Liese, K. Seelbach, C. Wandrey, Industrial Biotransformations, Wiley-VCH, 2006

Responsible for Module:
Sieber, Volker; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0257: Molecular Biology and Genetics | Molekularbiologie und Gentechnik [MolBio]

Version of module description: Gültig ab summerterm 2023

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 8	**Total Hours:** 240	**Self-study Hours:** 150	**Contact Hours:** 90

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The performance of the exam consists of a written test (90 min) in which the students show that they are able to call up and structure their theoretical and practical knowledge and use it on problems. By creating written protocols of the executed laboratory experiments (for each experiment about 5 pages of protocol), the students prove that they can documentate and illustrate theoretical principles as well as the results and the corresponding analysis and assessment of the experiments (not graded course achievement).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successfully completed exam for the Cell- and Microbiology module (CS0256) or an equivalent module. As a prerequisite for participation in the practical course, the written examination for the lecture must be successfully passed.

Content:
molecular structure of DNA, plasmids, bacteriophages, mutagenesis strategies, bacterial genomes, prokarotic gene regulation, transformation of organisms, genetic engineering, genetic engineering regulation, genome editing, cloning of DNA fragments, heterologous gene expression, analysis methods for DNA, RNA and proteins

Intended Learning Outcomes:
After completion of the modul the students possess knowledge about the most important molecular biological methods. They know how to isolate, analyse and manipulate nucleic acids and possess knowledge about the transformation of microorganisms. They understand what a genetically engineered organism is and can assess the risks and benefits of genetic engineering experiments,

including the benefits of new transgenic strains for sustainable production processes. The students can perform and analyse molecular biological experiments and name possible sources of error.

Teaching and Learning Methods:
The theoretical basics of the experiments conducted in the practical course will be delivered in the lecture part via ppt-presentations, movies and white board. In the practical course, the students will self-reliantly perform, document and analyse their experiments.

Media:
PowerPoint, blackboard work, practical course script

Reading List:
Molekularbiologische Methoden 2.0, T. Reinard, Utb, 2. Auflage, ISBN: 978-3-8252-8742-9
Mikrobiologie, J. L. Slonczewski, J. W. Foster, Springer Spektrum, 2. Auflage, ISBN: 978-3-8274-2909-4
Genome und Gene, T. A. Brown, Spektrum, 3. Auflage, ISBN: 978-3-8274-1843-2
Gentechnische Methoden, M. Jansohn, S. Rothhämel, Springer Spektrum, 2. Auflage, ISBN: 978-3-8274-2429-7
An Intro to Genetic Engineering, Desmond S. T. Nicholl, 3ed., Cambridge University Press, ISBN: 978-0521615211

Responsible for Module:
Prof. Dr. Bastian Blombach

Courses (Type of course, Weekly hours per semester), Instructor:
Molekularbiologie und Gentechnik (Vorlesung) (Vorlesung, 2 SWS)
Blombach B [L], Blombach B

Molekularbiologie und Gentechnik (Praktikum) (Praktikum, 4 SWS)
Blombach B [L], Blombach B, Glawischnig E, Hädrich M, Vital S
For further information in this module, please click campus.tum.de or here.

Compulsory Courses Area Process Engineering | Pflichtmodule Bereich Verfahrenstechnik

Module Description

CS0001: Foundations of Programming | Foundations of Programming [FoP]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Exam achievement shall be done in the form of a 90 minutes written test (either written or e-test). Knowledge questions check the treated basic concepts of programming and algorithms. Small programming and modeling tasks test the ability to apply the learned programming language in order to solve simple problems.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:

Content:
In the module following contents are treated exemplarily:
Python as a programming language:
- Basic concepts of imperative programming (if, while, for, lists, dictionaries etc.)
- File handling (reading, processing, writing etc.)
- Object-oriented programming (inheritance, interfaces, polymorphism etc.)

Basic algorithms and data structures:
- Recursion
- Search (e.g., binary search, balanced search trees)
- Sorting (e.g., Insertion-sort, selection-sort, quick-sort)

In the lectures and exercises, practical problems on real-world issues and topics related to sustainability are addressed, computer science-based solutions are developed and discussed.

Intended Learning Outcomes:
Upon successful completion of this module, students will be able to understand important fundamental concepts of programming, algorithms, and data structures. They will be able to apply the concepts learned to develop their own code and basic algorithms for scientific data analysis.

Teaching and Learning Methods:
Lectures to provide students with all the necessary programming and algorithmic fundamentals needed to independently develop their own analysis scripts and pipelines for scientific data analysis. In the labs, students will work on various programming tasks and write their own code to analyze specific case studies and real-world data.

Media:
Slide presentation, blackboard, lecture and exercise recording, discussion forums in e-learning platforms; Exercise sheets, Working on the PC

Reading List:
Learning Scientific Programming with Python, Christian Hill
Data Structures & Algorithms in Python, Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser

Responsible for Module:
Grimm, Dominik; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Foundations of Programming (Exercise) (Übung, 2 SWS)
Grimm D [L], Eiglsperger J, Martello S

Foundations of Programming (Lecture) (Vorlesung, 2 SWS)
Grimm D [L], Grimm D
For further information in this module, please click campus.tum.de or here.

Module Description

CS0038: Advanced Mathematics 2 | Höhere Mathematik 2

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Learning outcomes are verified in a written exam. The exam consists of assignments in which the students are to demonstrate that they understand the mathematical methods conveyed as part of the module and are able to apply them to specific examples. Exam duration: 90 minutes

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Advanced Mathematics 1

Content:
Selected topics from linear algebra, vector analysis, and ordinary differential equations that are required in engineering. In particular: vector spaces, bases, linear maps, matrix representation of linear maps, functions of several variables, partial and total differentiation, Taylor expansion, basic multivariate integration, basics of ordinary differential equations. The methods are presented during the lecture and are applied to specific examples related to sustainability in the exercise classes.

Intended Learning Outcomes:
After completion of the module, students understand the fundamental concepts and important methods from vector analysis and ordinary differential equations as well as the required prerequisites from linear algebra. They are able to apply mathematical arguments in these fields independently. Moreover, they can apply the central proof techniques and concepts of vector analysis and ordinary differential equations and comprehend their mathematical background.

Teaching and Learning Methods:
Lecture using digital presentation and/or blackboard to convey contents and methods. In addtion, concrete examples are discussed in the exercise classes through independent work and group work in order to practice the adequate expression and independent application of mathematical arguments.

Media:
Blackboard, slides, exercise sheets

Reading List:
K. Königsberger, Analysis 1, 6. Auflage, Springer 2004.
K. Königsberger, Analysis 2, 5. Auflage, Springer 2004.
C. Karpfinger, Höhere Mathematik in Rezepten, 3. Auflage, Springer Spektrum 2017

Responsible for Module:
Thielen, Clemens; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0199: Statistics | Statistics

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Learning outcomes are verified in a written exam. The exam consists of assignments in which the students are to demonstrate that they understand the statistical methods conveyed as part of the module and are able to apply them to specific examples. Exam duration: 90 minutes

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Qualification for university entrance; good mathematical knowledge is an advantage.

Content:
Selected statistical methods required in natural sciences, engineering, or economics, especially from the fields of descriptive statistics (e.g., graphical representation of uni- and bivariate data, measures of location and spread, measures of association for bivariate data, descriptive linear regression), probability calculus, and statistical inference (e.g., confidence intervals, hypothesis tests). The methods are presented during the lecture and are applied to specific examples related to sustainability in the exercise classes.

Intended Learning Outcomes:
The students know the most important statistical methods required in natural sciences, engineering, or economics. They have understood these methods, are able to select and perform suitable statistical procedures for specific case studies, and can draw correct conclusions from the results. Furthermore, the students should be aware of the capabilities and limitations of the presented statistical methods and are able to perform simple statistical analyses using statistical software (e.g., R).

Teaching and Learning Methods:
Lecture using digital presentation and/or blackboard to convey contents and methods. In addition, concrete examples are discussed in the exercise classes through independent work or group work.

Media:
Slides, blackboard, exercise sheets, e-learning

Reading List:
Diez, Cetinkaya-Rundel, Barr: OpenIntro Statistics, 4th edition, https://www.openintro.org/book/os/ (2019).
Fahrmeir, Heumann, Künstler, Pigeot, Tutz: Statistik - Der Weg zur Datenanalyse, 8. Auflage, Springer Spektrum (2016).
Field, Miles, Field: Discovering Statistics Using R, SAGE Publications (2012)
Caputo, Fahrmeir, Künstler, Lang, Pigeot, Tutz: Arbeitsbuch Statistik, 5. Auflage, Springer Verlag (2009).

Responsible for Module:
Thielen, Clemens; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Statistics (Lecture) (Vorlesung, 2 SWS)
Thielen C [L], Thielen C

Statistics (Exercise) (Übung, 2 SWS)
Thielen C [L], Thielen C
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1936: Mixture Thermodynamics and Mass Transfer | Thermodynamik der Mischungen und Stofftransport

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The exam performance is effected by a written test. The familiarising of the students with the basics and methods of molecular mass transport and the thermodynamics of mixed phases as well as the reference to real assignment of tasks is reviewed by calculations and by the evaluation of diagrams. The students prove the comprehension of the content of the module by application of the learned relations. Thereby the whole procedural spectra is extended for the chemical and material topics. The students calculate chemical equlibria and phase equilibria. Exam duration: 120 minutes.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basics of Mathematics, Physics and Chemistry, Physical Chemistry

Content:
Introduction to phenomenological thermodynamics, data on chemical media, mass transport phenomena and equilibrium state. Graphical presentation of state variables, thermal state equations for ideal and real pure substances, Gibbs's Thermodynamics, application of the Maxwell's relations (Maxwell's equations), caloric standard data, thermodynamics of mixtures, calculation of chemical and phase equilibria, basics of molar transition and equilibria in one and between several phases (mass transition, diffusion processes, mass transfer), chemical potential, ideal and real phase equilibria, equilibrium coefficients, equilibrium diagrams, mass/ energy/ momentum balance, Fick´s law, film theory, penetration theory.

Intended Learning Outcomes:
The lecture is aimed at familiarising the students with the basics and methods of molecular mass transport and the thermodynamics of mixed phases. Thereby they are qualified to understand the different calculation methods for material properties and phase equilibria in process engineering and to estimate their application possibilities and limits. Thereby the basics for further understanding of thermal and chemical processes are laid.

Teaching and Learning Methods:
The module consists of a lecture during which also exercises will be performed alternately. Contents of the lecture shall be imparted in speech and by presentation. To deepen their knowledge students shall be encouraged to study the literature and examine with regards to content the topics. In the exercises performed as part of the module learned theory shall directly be applied with a practical orientation by means of arithmetic examples.

Media:
Presentations, slide scripts, exercises

Reading List:

Responsible for Module:
Burger, Jakob; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Thermodynamik der Mischungen und Stofftransport (Vorlesung) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J

Thermodynamik der Mischungen und Stofftransport (Übung) (Übung, 2 SWS)
Rosen N [L], Burger J, Rosen N
For further information in this module, please click campus.tum.de or here.

Module Description

CS0208: Reaction Engineering and Fluid Separations | Chemische und Thermische Verfahrenstechnik

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 8	**Total Hours:** 240	**Self-study Hours:** 135	**Contact Hours:** 105

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcomes of the students will be tested in a written exam. There will be computational tasks on reaction engineering as well as thermal separation processes and reaction engineering. Students demonstrate that they can diagram and explain kinetics in engineering reactors. They demonstrate that they can answer questions about the fundamentals of catalysis. The design and balancing of process steps and the application of basic concepts and relationships in thermal separation technology will be examined. On the basis of various tasks (including computational tasks), the ability to solve the acquired knowledge to solve basic process engineering problems (design of stirrers, tubular reactors, etc.) within a limited time is tested.
Duration of examination: 120 minutes, auxiliary means: Four A4 pages of any written / printed paper and a non-programmable pocket calculator.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Fundamentals of Thermodynamics (CS0065), Mixture thermodynamics and mass transfer (WZ1936), General Chemistry (WZ1922)

Content:
Reaction kinetics, catalysts, features of homogeneous and heterogeneous catalysis; chemical reaction technology: homogeneous/heterogeneous reactions, reactor forms (e.g. stirrer tanks, tube reactor, packed bed, fluidized bed), indicators for reactor types (e.g. reaction vessels, flow tube), types of reaction control (e.g. fixed, not fixed, continuous, isothermal), flow conditions, and residence time behavior in reactors, heat balance of reactors, strategies for optimizing reaction control. Introduction to fluid separation processes, design methods (calculation and graphical), single-stage and multi-stage operations, Mc-Cabe-Thiele-Construction, HTU-NTU-concept, fixed-

point construction for extraction columns, feasibility limitations of unit operations. Applications in the field of distillation, absorption, extraction, membranes, adsorption.

Intended Learning Outcomes:
After having participated in the module the students are familiar with the most important reaction types and parameters of chemical catalysis and reaction technology and are able to apply suitable reaction controls for predefined chemical reactions, to perform kinetic calculations for common reaction types as well as to calculate parameters such as residence time behavior and heat demand of reactors. Thus, they are capable of also transferring methods learned from examples to new processes. After completion of the module, the students are able to design and assess the fluid separation processes distillation, extraction, absorption and membranes based on state diagrams. In addition, the students understand the basic principles of the said separation processes and the apparatus employed in an industrial context.

Teaching and Learning Methods:
The module consists of lectures and parallel tutorials. Contents of the lecture shall be imparted in speech and by presentation. To deepen their knowledge students shall be encouraged to study the literature and examine with regards to content the topics. In the exercises performed as part of the module, learned theory shall directly be applied with a practical orientation by means of arithmetic examples.

Media:
Supporting videos, script presentation sheets, exercise sheets

Reading List:
O. LEVENSPIEL: Chemical Reaction Engineering. 3. Auflage, John Wiley & Sons, New York (1998)
G. EMIG, E. KLEMM: Chemische Reaktionstechnik. 6. Auflage, Springer Vieweg, Berlin (2017)
SATTLER, K.: Thermische Trennverfahren: Grundlagen, Auslegung, Apparate, 3. Auflage, Wiley-VCH, Weinheim, 2002.

Responsible for Module:
Prof. Jakob Burger

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1939: Practical Course Process Engineering | Praktikum Allgemeine Verfahrenstechnik [PVT]

Version of module description: Gültig ab winterterm 2017/18

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The service is provided in the form of written protocols of the laboratory tests carried out (about 5 experiments and about 4 pages of protocol per experiment). In these, students should prove that they are able to understand the theoretical basis of the experiments, to document their experiments, and to evaluate their results. In addition, they should show that they can discuss deviations from the expected results and possible causes. Evaluation of the practical course as passed/failed. The practical course is only considered passed if the above-mentioned protocol meets the criteria of completeness, correctness and comprehensibility/clarity to more than 50% in each case, whereby feedback is given on a first draft.

Repeat Examination:

(Recommended) Prerequisites:
Chemical and thermal process technology, Technical Thermodynamics, Chemical Thermodynamics and Mass Transport

Content:
Basic operations of process engineering, especially from the chemical, thermal and mechanic range e.g. destillation or particle distribution analysis.The content and the number of experiments are chosen from a of multiplicity of basic operations and rely on the available laboratory equipment.

Intended Learning Outcomes:
After graduation of the practical course, the students know basic processes and principles of process engineering (e.g. destillation, extraction, desiccation or particle distribution analysis and

separation from a gas flow). They know how to design and calculate a chemical, physical or mechanic transformation. Furthermore, they know the process steps which are necessary for it.

Teaching and Learning Methods:
The acquisition of basic principles is prepared by handed out literature.
The student learns the theoretical understanding, the basic engineering of the experiment and the correct use of the installed measurement technique through the graduation of the practical course. The acquisition of these properties is proved at the day of the experiment and comfirmed by producing a report. Thereby also the ability is reviewed to evaluate and report data correctly.

Media:
Practical course script, laboratory equipment

Reading List:
Practical course script, standards: DIN EN ISO 106281-1 and DIN EN ISO 10628-2. The literature is provided at the beginning of the module and does not have to be procured by the student.

Responsible for Module:
Burger, Jakob; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Praktikum Allgemeine Verfahrenstechnik (Praktikum, 5 SWS)
Burger J [L], Burger J, Rosen N, Staudt J, Winklbauer L, Wolf C
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1940: Bioprocess Engineering | Bioverfahrenstechnik [BPE]

Version of module description: Gültig ab summerterm 2023

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
To proof whether the students acquired detailed and differentiated knowledge about concepts, calculations and the general design of various bioprocesses, a written examination takes place with a duration of 90 minutes.

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
The lecture provides a fundamental overview of bioprocess engineering including all relevant process parameters, calculations and balances.This includes basic calculations of generation times, maximal specific growth rates as well as balancing of batch, fed-batch and continous fermentation processes. Furthermore, process relevant parameters such as oxygen transfer rates and heat transfer will be conveyed. Additionally, basic operation unit design as well as scale-up aspects will be examined. Examples of sustainable production processes are also given that use renewable raw materials, are climate-friendly and less harmful to the environment than conventional processes.

Intended Learning Outcomes:
The students acquire detailed and differentiated knowledge about concepts of various bioprocesses. Finally they are able to describe, calculate and design classical as well as complex bioprocesses. They will be able to evaluate the applicability of mathematical modelling of bioprocesses and will use this knowledge to analytically simplify highly complex process variants.

Teaching and Learning Methods:
The lecture will be performed as ex-cathedra teaching to provide the students will all necessary fundamentals. Within the tutorial the students learn how to transfer this knowledge and get practically used with the content of the lecture. The tutorial will be used to internalise the theoretical knowledge based on case studies which allows the transformation on real-world as well as highly specific challenges of bioprocesses.

Media:
Slides, interactive quizzes, scripts, exercise sheets

Reading List:

Responsible for Module:
Prof. Dr.-Ing. Michael Zavrel Nico Geisler

Courses (Type of course, Weekly hours per semester), Instructor:
Bioverfahrenstechnik (Übung) (Übung, 2 SWS)
Geisler N, Zavrel M

Bioverfahrenstechnik (Vorlesung) (Vorlesung, 2 SWS)
Zavrel M
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1941: Practical Course Bioprocess Engineering | Praktikum Bioverfahrenstechnik [PCBPE]

Version of module description: Gültig ab summerterm 2023

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
At the beginning of the practical course, there is a colloquium to ensure that the students have read the internship script/topic sufficiently. The data obtained in the practical tests must be evaluated and analyzed scientifically. Test protocols must be submitted. Passing or failing the module is assessed on the basis of the student's performance in the colloquium, the practical laboratory work and the protocol submitted.

Repeat Examination:

(Recommended) Prerequisites:
Module Bioprocess Engineering

Content:
The practical course serves to deepen the content developed in the lecture Biochemical Engineering. In the internship, the theoretically conveyed basics are deepened by means of selected experiments. These practical experiments include the analysis of typical bioprocess parameters such as the determination of the specific growth rate. In addition, process-relevant offline parameters (e.g. the dry biomass) and online parameters (e.g. O2 and CO2 concentration in the exhaust gas) are recorded experimentally. Through the practical course, the students learn how to develop and optimize sustainable bioprocesses that are more climate-friendly than many conventional processes and help to reduce environmental pollution.

Intended Learning Outcomes:
After participating in the practical course, the students are able to work practically with bioreactors and scientifically evaluate fermentation processes. In addition, the students are able to transfer the

calculations and practical experience they have learned to other complex processes and to use the resources of energy, water and raw materials efficiently.

Teaching and Learning Methods:
The practical course is based on carrying out cultivations in shake flasks and bioreactors. Bacteria and/or yeasts are used as the cultivation organism. Particular value is placed on the students' own initiative in order to promote a solution-oriented and independent way of working. The technical process characteristics are calculated and evaluated based on the recorded data.

Media:
slides, scripts, bioreactor

Reading List:

Responsible for Module:
Prof. Dr.-Ing. Michael Zavrel Dennis Beerhalter Nico Geisler

Courses (Type of course, Weekly hours per semester), Instructor:
Praktikum Bioverfahrenstechnik (Praktikum, 5 SWS)
Zavrel M [L], Stegemeyer U, Zavrel M
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1942: Process Design Project | Anlagenprojektierung

Version of module description: Gültig ab winterterm 2017/18

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 60	**Contact Hours:** 90

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The exam performance consists of a project planning in the group and preparation of a group presentation of the main results of the project treatment in the group that records the assignment of tasks, the detailed course of action of the students and the calculation as well as the beyond obtained results. The presentation shows whether the students have learned all the steps which belong to the design of a technical process. The completion of the project work constitutes of a short presentation (15 min) of the students.Thereby the presentation is performed to the other participants of the module (not graded course achievement).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Chemical and thermal process technology, Technical Thermodynamics, Chemical Thermodynamics and Mass Transport

Content:
The content consists of a project work in basic engineering and the corresponding design of a exemplary process or of parts of the process, the usage of calculation tools (like Excel, Mathcad), the examination of profitability and of the basics of project management in line with the teamwork.

Intended Learning Outcomes:
After completion of the module the students know how to approach the planning of a technical assignment of tasks. They are able to acquire required informations, to dimension the system in a correct way and examinate its profitability. So the students can design technical processes. Thereby the reference to real design is laid and the students are able to apply basic work steps.

Teaching and Learning Methods:
The groups are tackled with a design task which can be solved by a correct information search and execution of sub-steps. The formulation of solution(s) is carried out in groups consisting of 2 to 4 students. The lecturers support this learning process by continuous interaction. Thereby the knowledge is intensified in supervised teamworks whereby the expertise is clearly strengthened.

Media:

Reading List:

Responsible for Module:
Burger, Jakob; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Anlagenprojektierung (Praktikum und Übung) (Praktikum, 6 SWS)
Gaderer M [L], Herdzik S, Huber B, Meilinger S, Putra L, Schenker M, Veiltl P

Anlagenprojektierung (Praktikum, 6 SWS)
Zavrel M [L], Beerhalter D, Borger J, Dsouza V, Geisler N, Marino Jara J, Oktay I, Stegemeyer U, van der Walt H, Zavrel M
For further information in this module, please click campus.tum.de or here.

Research Internship | Forschungspraktikum

Module Description

WZ1943: Research Internship | Forschungspraktikum

Version of module description: Gültig ab winterterm 2017/18

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 60	**Contact Hours:** 240

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Exam achievement consists of a graded practical course report (10-15 pages) about contents and results of the practical course containing at least an overview of the level of knowledge relating to the project subject as well as representation of used working methods and a representation of the results including interpretation. In a final grade quality of familiarisation with the topic of experimental work, interpretation of results and written elaboration shall be evaluated.

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
Research-related works at the chairs and working groups of the TUM Campus Straubing. The students shall each get tasks from the research field of the mentoring examiner. They shall work on these tasks under supervision in form of projects. Topics have to be allocated with regard to content and expertise to one of the core themes (cultivation, economy, material use, energetic use). The students shall largely independently plan project works under supervision of the mentors. Project works shall be documented and evaluated in form of an internship report. Optionally a completing presentation of work progress may be done in form of oral presentations. Project works can also be done in cooperation with external institutions, e.g. companies.

Intended Learning Outcomes:
After having participated in the module the students especially understand principles of approach to (research) projects, planning of project works and critical evaluation of project results beside

subject-specific knowledge and working methods each imparted in the practical course in scientific working. The students will be able to apply these principles to new project tasks. Besides they are able to document, to interpret and summarise project works and results in a meaningful way in written form.

Teaching and Learning Methods:
According to the core theme and topic, e.g. experimental equipment (laboratory), databases, libraries, subject-specific software, project and experiment design software

Media:
dependent on focus and topic e.g. experimental equipment (lab), databases, libraries,subject-specific software, project/ experiment planning software

Reading List:
Technical literature

Responsible for Module:
Prof. Volker Sieber

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Bachelor Pflichtmodul (Praktikum, 10 SWS)
Blombach B [L], Blombach B, Glawischnig E, Hädrich M, Vital S

Forschungspraktikum Bachelor Pflicht (Forschungspraktikum, 10 SWS)
Sieber V [L], Abbas Nia A, Al-Shameri A, Arana Pena S, Dsouza Z, Fornoni E, Friedrichs J, Fuchs A, Giustino A, Grundheber J, Hofer N, Hörnschemeyer K, Hupfeld E, Kampl L, Köllen T, Liu Y, Malubhoy Z, Marosevic M, Matena F, Mayer M, Ostertag T, Raga Carbajal E, Rau M, Romeis D, Rühmann B, Scheerer J, Schieder D, Schulz M, Sieber V, Siebert D, Skopp A
For further information in this module, please click campus.tum.de or here.

Electives | Wahlmodule

Technical Electives | Fachspezifische Wahlmodule

Module Description

CS0035: Principles and Methods of Synthetic Biology | Principles and Methods of Synthetic Biology

Version of module description: Gültig ab summerterm 2023

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Achievement of the desired learning objectives will be verified in a written final exam (90 minutes). In the exam, the students demonstrate that they know, understand and can explain the key concepts and methods of synthetic biology. The students will also demonstrate that they are able to make predictions of the functions of synthetic gene regulatory circuits and that they can discuss risks and benefits of synthetic biology applications.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Molecular biology and genetics

Content:
- History and principles of synthetic biology
- Gene synthesis and large-scale DNA assembly
- Synthetic gene circuits
- CRISPR/Cas tools and applications
- Sensors and actuators
- Top-down and bottom-up construction of artificial cells
- Examples of synthetic biology applications in medicine, sustainable biomanufacturing, and environmental sensing and remediation

- Ethical considerations and ways to address them, potential impacts of synthetic biology on environment and society

Intended Learning Outcomes:
After successful participation in the module, students are able to explain key concepts of synthetic biology like standardization of biological parts and rational design of new biological functions. They can describe key methods and applications of synthetic biology. Furthermore, students understand the principles of regulatory circuit design and are able to predict the functions of synthetic circuits. They are able to discuss synthetic biology applications, for example in sustainable bioproduction. They are also able to discuss ethical considerations and to identify risks and benefits in synthetic biology experiments.

Teaching and Learning Methods:
The contents of the lectures are conveyed by a talk of the lecturer based on slide-supported presentations. The blackboard will be used to explain complex relationships. The content of the lecture with be supplemented by self-study of literature on synthetic biology applications that is provided to students. Synthetic biology applications and their ethical considerations will be actively discussed by students during the lecture to promote critical reflection.

Media:
Slides, whiteboard

Reading List:
The material in the lecture is sufficient for learning and is provided in the lecture.

Responsible for Module:
Prof. Henrike Niederholtmeyer

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0042: Microscopy and Diffractometry | Mikroskopie und Diffraktometrie [MikDif]

Version of module description: Gültig ab winterterm 2020/21

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The course will be evaluated in a 90 minute written exam.
In the examination, students shall demonstrate their knowledge about the typical structure-determination methods applied in research and industry, including the specific implementations and the obtainable data. Based on posed scenarios, they shall demonstrate their ability to perform typical evaluation sequences.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamentals of materials science,
Instrumental analytics and spectroscopy

Content:
The module covers microscopic and diffractometric methods for the structural analysis of materials. In Detail, optical- and electron microscopy, in transmission- or scanning modes, respectively, and with analytic additions will be discussed. Further, methods of X-ray diffraction, in the Small- as well as Large-angle regions will be discussed. In the exercises, the evaluation methods discussed in the lecture will be practiced.

Intended Learning Outcomes:
After completion of the module, participants are enabled to name the correnponding dimensional scales that can be assessed with the discussed methods. They can give the technically achievable measurement parameters and the information that can be obtained from the data. They can permform the respective elavuations independently and know typical error sources.

Teaching and Learning Methods:
In addition to the lecture, demonstrations will be carried out at the machines. Problems will be solved cooperatively to deepen the knownledgge about microscopy and diffractometry.

Media:
Blackboard, slides

Reading List:

Responsible for Module:
Dr. Daniel van Opdenbosch

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0106: Introduction to Graphs and Networks | Einführung in Graphen und Netzwerke [EGN]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** irregularly
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Assessment takes an oral form (25 minutes). Students show the extent to which they have understood the taught definitions and terminology from the field of graphs and networks. They show to which extend they are able to use networks in order to model problems from science and engineering. They are also expected to use appropriate methods to solve fundamental optimization problems on networks. Students demonstrate their understanding of these methods when answering comprehension questions.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Module Mathematics (WZ1601) or Advanced Mathematics 1 (CS0175)

Content:
Directed and undirected graphs and networks, paths and cycles, connected components, minimum spanning tree problem, shortest path problem, Prim's algorithm, Kruskal's algorithm, Dijkstra's algorithm, matchings, Modeling with graphs and networks

Intended Learning Outcomes:
Students have aquired basic theoretical and practical knowledge in the field of graphs and networks. They know the basic definitions and terminology and are able to use networks in order to model problems from science and engineering. Students know fundamental optimization problems on networks such as the minimum spanning tree problem or the shortest path problem as well as the most important methods for solving these problems. They have gained a good understanding of these methods, can choose appropriate methods among them, and can apply these to case examples.

Teaching and Learning Methods:
Lectures introduce basic knowledge; tutorials practice modelling using networks and the application of methods for solving optimization problems on networks.

Media:
Lectures given as presentations (projector and/oder blackboard), tutorials with group work and exercise sheets

Reading List:
André Krischke und Helge Röpke - Graphen und Netzwerktheorie, Carl Hanser Verlag, 2015.
Sven Krumke und Hartmut Noltemeier - Graphentheoretische Konzepte und Algorithmen, 3. Auflage, Vieweg+Teubner Verlag, 2012.
Ravindra Ahuja, Thomas Magnanti, James Orlin - Network Flows, Prentice Hall, 1993.

Responsible for Module:
Prof. Clemens Thielen

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0108: Catalysis | Catalysis

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Results will be assessed by a written exam (90min), whereby the students explain important facts of technical catalysis chemistry, mechanistic aspects of catalysts how catalysts work, what is their typical composition and show practical applications by using examples.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic organic and inorganic chemistry

Content:
transition metal compounds, homogenous/heterogenous catalysis, mechanistic details of activation of organic and inorganic molecules at transition metal compounds, surface chemistry, characterisation of catalysts, heat/mass transfer at catalyst grains, reactor designs

Intended Learning Outcomes:
Students can show important chemical aspects of the phenomenon of catalysis with simple examples. They can show the implication of a catalyst in an overall reaction and can quantify it mathematically by using typical measurable values.

Teaching and Learning Methods:
Using lectures, basic principles of catalysts and catalysis will be transmitted.

Media:
Power point presentation, table, oral teaching, discussion

Reading List:
Dirk Steinborn, Grundlagen der metallorganischen Komplexkatalyse, Vieweg und Teubner Verlag, 2. Auflage 2009 (434 Seiten, 41 €).

Responsible for Module:
Riepl, Herbert; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Catalysis (Lecture) (Vorlesung, 3 SWS)
Riepl H [L], Riepl H
For further information in this module, please click campus.tum.de or here.

Module Description

CS0131: Applied Methods in Chemistry | Praktische Methoden in der Chemie

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Exam achievement shall be done in the form of laboratory performance (e.g. preparation, performance (ca. 15 experiments depending on topic) and written evaluation (ca. 20 pages)) combined with a ten-minute presentation. Thus it shall be demonstrated that the working methods learned can be applied practically and transferred to the execution of test series. By means of the presentation communicative competence shall be verified when scientific topics are presented in front of an audience. Laboratory performance shall be evaluated with 2/3, the presentation with 1/3.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge and laboratory experience like in the modules of WZ1922/WZ1925 (LV4390 General and inorganic Chemistry und LV4400 Practical Laboratory Course General and inorganic Chemistry) and WZ1924/CS0215 (LV972 Organic Chemistry und LV936 Practical course in organic chemistry) shall be imparted.

Content:
The module makes use of different methods leading to the performance of test series. As a first step the students shall be lead to planning and performance of basic activities of laboratory practice by means of the lecture including thematisation of experiment design and research of literature as well as keeping the laboratory journal, how to use the most important and basic practical working methods as well as handling the most import laboratory equipment. In the next step the different working methods (including weighing, dissolving, diluting) shall be applied in supervised practical exercises. Subsequently individual test series shall be planned, processed and evaluated by the students after consultation with the lecturer.

Intended Learning Outcomes:
After having participated in the module units the students are capable of using basic working techniques (such as weighing, pipetting, dissolving, diluting) in the laboratory, of outlining simple test series, of performing an experimental design and of recognizing possible sources of errors.

Teaching and Learning Methods:
The module is successively built up using lecture, practical exercises and test series. In the lectures it is dealt with basic issues and methods necessary for the execution of subsequent exercises. After testing different methods in supervised exercises these methods will be transferred to a test series. Planning, performance and result evaluation will be summarised in a written assessment.

Media:
PowerPoint, Laboratory

Reading List:
Organikum, Lehrbuch der analytischen und präparativen anorganischen Chemie (Organikum, Textbook of Analytical and Preparative Anorganic Chemistry) (ISBN 978-3527339686) ; 1x1 der Laborpraxis (Basics of Laboratory Practice (ISBN 978-3527316571)

Responsible for Module:
Dr. Corinna Urmann

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0164: Basics of Numerical Methods and Simulation | Basics of Numerical Methods and Simulation [NumS]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Examination shall be done in the form of a written test. As an aid the materials (lecture slides, example programs) used during the lecture may be employed. The students show by solving programming tasks that they know the basics of Matlab and are able to employ it to implement simple numerical methods. They apply these methods to specific technical problems in case studies. In doing so, they also demonstrate their capability to discern which way to solve a problem is appropriate.
Exam duration: 90 minutes

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
WZ1600 Physics, CS0 Mathematics

Content:
- Basics of programming using Matlab/Simulink
- simple numerical methods: Systems of linear equations, numerical integration & differentiation, finding zeros,
- numerical solution of differential equations
- application of methods by using case studies (e.g. mechanical and electric systems)
- basics of optimization

Intended Learning Outcomes:
After having participated in the module units the students understand basic concepts of various numerical methods. They can apply these methods to case studies presented in the course methods using self-created programs in Matlab/Simulink. In doing so, they have also learned

to implement different solutions and discern how appropriate to the problem they are. In simple cases, they are also able to evaluate their results in terms of plausibility and accuracy.

Teaching and Learning Methods:
The module consists of one lecture and an associated session of exercises. Contents of the lecture shall be imparted in a speech and deepened through independent preparation of exercises by the students. Processing of exercises is often done by independent preparation of programming tasks.

Media:
Presentations, writing on the board, demonstration of programmes/scripts

Reading List:

Responsible for Module:
Kainz, Josef; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0180: Concepts of Physics and Chemistry in Nature | Concepts of Physics and Chemistry in Nature

Version of module description: Gültig ab summerterm 2022

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The performance test will be in the form of a written examination. The students should demonstrate in the exam the understanding of the physicochemical principles governing natural systems. They will be asked about
Basic concepts of physical chemistry applied to energy conversion in natural systems and to the structure of biomolecules. No auxiliary means are allowed in the exam. 120 min examination time

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
This course will intend to consolidate basic concepts in Physics, Mechanics, Chemistry, and Mathematics having the focus on Nature examples. As such, basic knowledge in Physics, Chemistry, Mechanics, and Mathematics is required.

Content:
The module aims at providing in-depth knowledge to the students in the field of Physics and Chemistry applied to Biology. The focus on basic physical and chemical laws, concepts, principles and processes, including chemical bonding, chemical kinetics, spectroscopy, thermodynamics, thermochemistry, mechanics, optics, among others. The students will be able to apply them to understand the functionality of biological compounds/materials towards a more practical vision of Nature and its possible technological application.
The course will be divided into several topics related to the chemical structure of proteins, sugars, and other bio compounds, the formation of micro and macro self-assembled structures, light manipulation, heat management, mechanics, and electrical control. Each topic will be addressed refreshing the most important physical and chemical concepts followed by their relevance in the structural and functional aspects of these materials and their possible application in technology.

Intended Learning Outcomes:
At the end of the module students will be able to analyse biological systems using a physicochemical perspective; describe the different ways energy is transformed and used by natural systems (thermally, optically, mechanical etc.). They will be able to analyse the structure of proteins and other biomolecules and to identify the forces that define their functionality. They will be able to apply these concepts to understand bio-based and bio-inspired technologies.

Teaching and Learning Methods:
This course attendance includes lectures and exercises. For this purpose, powerpoint presentations, practical training materials, and open discussion seminars will be used.

Media:
The following forms of media apply: powerpoint, films, and blackboards.

Reading List:
1. Physical Chemistry for the Biological Sciences, 2nd Edition Gordon G. Hammes, Sharon Hammes-Schiffer, Wiley, 2015, ISBN: 978-1-118-85900-1
2. Physical Chemistry for the Life Sciences, 2ndEdition Peter Atkins and Julio De Paula Oxford University Press ISBN: 978-0-19-956428-6
3. Introduction to Biophotonics Paras N. Prasad Wiley 2003, ISBN: 0-471-28770-9.
4. Introduction to Biomechanics Duane Knudson Springer 2007 ISBN: 978-0-387-49311-4

Responsible for Module:
Costa Riquelme, Rubén Dario; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Concepts of Physics and Chemistry in Nature (Lecture) (Vorlesung, 2 SWS)
Costa Riquelme R [L], Banda Vazquez J, Costa Riquelme R, Zieleniewska A

Concepts of Physics and Chemistry in Nature (Exercise) (Übung, 2 SWS)
Costa Riquelme R [L], Banda Vazquez J, Costa Riquelme R, Zieleniewska A
For further information in this module, please click campus.tum.de or here.

Module Description

CS0191: Downstream Processing | Downstream Processing [DSP]

Downstream Processing

Version of module description: Gültig ab summerterm 2024

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The teaching content will be evaluated by a written examination for the learning outcomes of the module of a duration of 60 minutes. Based on questions to definitions and methods of downstream processes of biologically inspired processes the students prove that they know the corresponding technical terms, designations and contents, that they have understand the basic relations and are able to apply their knowledge. Using calculations, the students also show that they can calculate and design downstream processing methods.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Module Bioprocess Engineering

Content:
The lecture gives a basic introduction to the downstream processing technologies of bioprocesses, in which all relevant separation methods are discussed. The content ranges from the determination of the respective process variables to the design and scaling up of the technologies. One focus is on avoiding, minimizing and recycling waste streams in order to develop sustainable bioprocesses that conserve resources and do not pollute the environment. In the parallel exercise, the lecture content is deepened in the form of exercises to be worked on.

Intended Learning Outcomes:
After participating in the module events, the students are able to define the terminology of the processing technologies of bioprocesses. These include above all the different separation methods, which contribute significantly to the feasibility of fermentation processes and other biologically based manufacturing processes. At the end of the module, the students are able to

develop, design and implement economical and sustainable bioprocesses based on the application and implementation of these processing methods.

Teaching and Learning Methods:
The lecture takes place mainly as frontal teaching in order to familiarize the students with all the necessary basics, which they need for the assessment of targeted and sustainable downstream processes in the field of biotechnology. In the exercise, design tasks are worked on in order to learn how to calculate and design DSP processes.

Media:
slides, interactive quizzes, short films, scripts, exercise tasks

Reading List:
Harrison, Roger G, and others, Bioseparations Science and Engineering, 2nd edn (New York, 2015; online edn, Oxford Academic, 12 Nov. 2020), https://doi.org/10.1093/oso/9780195391817.001.0001, accessed 8 July 2024.

Responsible for Module:
Prof. Dr.-Ing. Michael Zavrel

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0217: Mechanical Process Engineering | Mechanische Verfahrenstechnik [MVT]

Version of module description: Gültig ab summerterm 2022

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination performance is provided in the form of a written examination. The students prove that they understand the structure and function of apparatuses and can carry out the basics of design, material selection and strength calculation. In the interaction of machines and apparatus, plant concepts are to be designed and/or specific aspects, such as the safety of operation, are to be discussed on the basis of P&Is.
Examination: written, duration: 90 minutes; auxiliary means: calculator

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Technical Mechanics (CS0036), Materials Science (CS0040), Fluid Mechanics (WZ1954)

Content:
The module teaches the basics necessary for the description of particle systems:
Particle size and shape, distribution functions, particle motion and interactions in heaps.
Furthermore, the basic operations applied to particles are presented: Crushing, mixing, separating, agglomerating, fixed and fluid beds, filtration.
For example, reference is made to applications in material and energy systems with regard to wood chipping, conveying, fermenter stirring and biomass combustion.

Intended Learning Outcomes:
After participating in the module, the students are able to apply the mathematical fundamentals of particle technology and to interpret the basic operations of particle process technology.

Teaching and Learning Methods:
The module consists of lecture and exercise.
The content of the module is conveyed during the lecture by speech and presentations. The students are encouraged to engage actively with the topics by integrating various self-search tasks and comprehension questions.
In the exercises, which take place in alternation with the lecture, serve for a stronger comprehension of the teaching contents. Hence, the students work on various calculation exercises and conduct different lab experiments in small groups.

Media:
Presentations, exercises

Reading List:
Bohnet, M., Hg.; 2014. Mechanische Verfahrenstechnik. Weinheim: Wiley-VCH-Verl. ISBN 9783527663569
Müller, W., 2014. Mechanische Verfahrenstechnik und ihre Gesetzmäßigkeiten. 2. Aufl. München: De Gruyter. Studium. ISBN 3110343568.
Rhodes, M.J., 2008. Introduction to particle technology. 2nd ed. Chichester, England: Wiley. ISBN 047072711X.
Schubert, H., 1990. Mechanische Verfahrenstechnik. Mit 36 Tabellen. 3., erw. und durchges. Aufl. Leipzig: Dt. Verl. für Grundstoffindustrie. Verfahrenstechnik. ISBN 9783342003816.
Schwister, K., Hg., 2010. Taschenbuch der Verfahrenstechnik. Mit 49 Tabellen. 4., aktualisierte Aufl. München: Fachbuchverl. Leipzig im Carl-Hanser-Verl. ISBN 3446424350.
Stiess, M., 1997. Mechanische Verfahrenstechnik 2. Berlin, Heidelberg: Springer Berlin Heidelberg. Springer-Lehrbuch. ISBN 978-3-662-08599-8.
Stiess, M., 2009. Mechanische Verfahrenstechnik. Partikeltechnologie. 3., vollständig neu bearbeitete Aufl. Berlin, Heidelberg: Springer Berlin Heidelberg. Springer-Lehrbuch. ISBN 978-3-540-32552-9.
Zogg, M., 1993. Einführung in die mechanische Verfahrenstechnik. Mit 29 Tabellen und 32 Berechnungsbeispielen. 3., überarb. Aufl. Stuttgart: Teubner. ISBN 9783519163190.

Responsible for Module:
Prof. Matthias Gaderer

Courses (Type of course, Weekly hours per semester), Instructor:
Mechanical process engineering (Exercise) (Übung, 2 SWS)
Gaderer M [L], Fang W, Herdzik S

Mechanical process engineering (Lecture) (Vorlesung, 2 SWS)
Gaderer M [L], Fang W, Herdzik S
For further information in this module, please click campus.tum.de or here.

Module Description

CS0230: Applied Electrochemistry | Angewandte Elektrochemie [Appl. EC]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The achievement of the learning objective is checked by a written examination (examination time: 60min). Up to 10% of the total number of points can be added to the grade of this written examination as bonus points. The results of the online tests held during the semester determine the amount of bonus points. At least 65% of the points in the online test must be achieved in order to receive bonus points. It is not possible to raise the grade from 4.3 or worse to 4.0. This should encourage the students to continuously participate in the lectures and exercises that are very important for them. By means of questions on electrochemical aspects, the students prove that they know the relevant technical terms, designations and contents, have understood the basic interrelationships and can apply their knowledge of the processes taking place within the framework of electrocatalysis, local electrochemistry as well as spectroelectrochemistry. Concrete computational tasks are set for this purpose.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Allgemeine Chemie and Physikalische Chemie, Mathematik, Physik, Einführung in die Elektrochemie or other introductory lectures to electrochemistry.

Content:
- Electrochemistry of surface-bound species: The ideal case (Langmuir isotherm) and deviations (Frumkin isotherm). Heterogeneous electron transfer (Laviron formalism) to surface-bound species.
- Local electrochemistry: electrochemistry at microelectrodes, scanning electrochemical microscopy.

- Electrochemistry at the nanoscale: mass transfer & kinetics at heterogeneous electrodes. Applications of nanoparticle-modified electrodes. Single nanoparticle electrochemistry.
- Electrocatalysis: Molecular electrochemistry - theory and practice. Heterogeneous electrocatalysis - theory and practice. Methods in electrocatalysis research (DEMS, ICP-MS, FTIR, Raman, etc). Applications (electrochemistry and electrocatalysis of CO2, O2 and H2).
- Spectro-electrochemistry: coupling of EPR, UV-Vis, IR, Raman spectroscopy with electrochemistry. Electropolymerisation/conducting polymers. Correlation between optical properties, energy levels and redox potentials.

Intended Learning Outcomes:
The students learn the advanced knowledge of fundamental concepts of electrocatalysis, local electrochemistry and spectroelectrochemistry with reference to specific application examples. They are able to deal with the general principles of electrocatalysis and local electrochemistry and apply them to simplified problems of real electrochemical systems. A special focus is put on the understanding of the general and temporal interplay of electron transfer, chemical reactions and mass transport, in different electrocatalytic systems. Special focus will be on the theory of surface bound species, as well as molecular, heterogeneous and nanoparticle electrocatalysts. Furthermore, students will be familiar with electrochemical characterisation methods and will be able to apply their theoretical knowledge to these areas. Furthermore, students are familiar with industrially relevant processes, renewable energy conversion, green electrosynthesis and sustainable energy production and storage and can apply their theoretical knowledge to these areas. In addition, they know electrochemical characterisation methods and can apply them to real examples to design and optimise processes in research and industry.

Teaching and Learning Methods:
In this lecture, the course content is delivered through lectures by the lecturer using a fluent PDF script, PowerPoint slides and blackboard images. This allows for a detailed presentation of the course content and students are able to ask and discuss questions as they arise. PDF-script, PowerPoint slides and blackboard images provide visual support to help students understand the complexities of electrochemistry. In addition, students are provided with exercises to consolidate the content learned in the lecture. The solutions to these exercises are later presented and discussed by the students in an exercise lesson.

Media:
Presentations, PowerPoint, script.

Reading List:
Electrochemical Methods: Fundamentals and Applications; Bard/Faulkner, ISBN-13: 978-0471043720

Responsible for Module:
Prof. Nicolas Plumeré Dr. Ben Johnson Dawit Tedros Filmon

Courses (Type of course, Weekly hours per semester), Instructor:
Angewandte Elektrochemie (Übung) (Übung, 1 SWS)
Plumeré N [L], Filmon D

Angewandte Elektrochemie (Vorlesung) (Vorlesung, 2 SWS)
Plumeré N [L], Plumeré N
For further information in this module, please click campus.tum.de or here.

Module Description

CS0243: Practical Course Electrobiotechnology | Praktikum Elektrobiotechnologie [EBTP]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 75	**Contact Hours:** 105

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment is done in the form of protocols of the laboratory experiments carried out (7 laboratory experiments per experiment 2-3 pages protocol). In these, the students have to evaluate the data obtained in the practical experiment and compare it with the predictions of the underlying theoretical model. The evaluation and discussion of the results are recorded in the protocol together with the correct description of the experimental procedure. In this way, the students should prove that they are able to understand the theoretical basis of the experiment, document their experimental performance, evaluate and discuss the measurement data obtained. The submitted protocols are graded according to completeness, correctness and comprehensibility/clearness, whereby a one-time correction of the protocols is possible. The protocol is considered passed if the criteria are fulfilled by more than 50%, consequently 4.0 or better.
The module is considered passed if all protocols are passed. In this case, the grade for the module results from the averaged grades of the protocols, i.e. (sum grade protocol 1-7)/7.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Successful participation in the module " Einführung in die Elektrochemie " as well as " Praktikum Allgemeine Chemie" and " Praktikum Biochemie ". In addition, knowledge of grammar school English.

Content:
During the block practical, several electrochemical experiments are carried out to characterise the active components. On the next day, the measurement results obtained are analysed together and compared with simulations of known models. On the basis of this, kinetic parameters are to

be determined (e.g., catalytic rate and Michaelis-Menten constant) as well as limits of the known models and sources of error are to be shown. The model systems used for this purpose are:
• Determination of the electrode surface by means of capacitive and potentiometric measurements.
• Voltammetry of freely diffusing redox mediators.
• Voltammetry of redox-active enzymes in solutions by mediated electron transfer.
• Measurement of glucose concentration by electrochemical methods.
• Voltammetry of redox-active enzymes immobilised on electrodes.
• Determination of the faradaic efficiency of biocatalytic NADP+ reduction using an FNR/V++ PVA-modified electrode.

Intended Learning Outcomes:
After successful participation in this module, the students are able to:
• handle electrochemical apparatus safely (potentiostats, electrochemical cells).
• carry out electrochemical measurements of biocatalytic systems (prepare the electrodes, set up a measuring apparatus and carry out potentiometric and voltametric measurements).
• analyse the measurement results obtained and determine kinetic and other parameters based on them.
• to use simulation software to obtain possible reaction mechanisms from the measurement data.
• to recognise sources of error in electrochemical experiments and to adapt the experiment.

Teaching and Learning Methods:
In the laboratory, the students learn the fundamentals of electrochemistry by carrying out experiments independently. In the process, students are directly supervised in small groups. In order to also gain a theoretical understanding of the underlying mechanisms and to learn the methods for analysing electrochemical measurement data, the analysis of the previously obtained data is carried out together. The theory is first discussed and then applied individually. Simple simulations are then carried out and the measurement results are compared quantitatively with the theory.
This inclusive approach should enable the knowledge to be conveyed as practically as possible, so that the students are then able to plan and carry out experiments independently and generate knowledge from them.

Media:
Slides, script, film, simulation software

Reading List:
Electrochemical Methods: Fundamentals and Applications; Bard/Faulkner, ISBN-13: 978-0471043720

Responsible for Module:
Prof. Nicolas Plumeré

Courses (Type of course, Weekly hours per semester), Instructor:
Praktikum Elektrobiotechnologie (Praktikum, 7 SWS)

Plumeré N [L], Ahmed M, Höfer T, Honacker J, Jaenecke J, Moore Y, Plumeré N
For further information in this module, please click campus.tum.de or here.

Module Description

CS0302: Research Internship Bachelor | Research Internship Bachelor

Version of module description: Gültig ab summerterm 2024

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:**	**Contact Hours:**

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:

Intended Learning Outcomes:

Teaching and Learning Methods:

Media:

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0304: Research Excursion Bachelor | Research Excursion Bachelor

B-REX

Version of module description: Gültig ab summerterm 2024

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** irregularly
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Passed/not passed:
The module is passed when the deliver a learning portfolio consisting of the following elements:
1. 2 written pages or 20’ presentationon preparatory work for the excursion. The form and the due date will be specified in the kick-off session.
2. At least two topical contributions to the excursion (topical input, interviews, questions on presentations and during site visits, discussion contributions);
3. 2 written pages reflection after excursion. The due date will be specified in the kick-off session.
All three elements of the learning portfolio have to be delivered to pass the module.

Repeat Examination:

(Recommended) Prerequisites:
Prerequisites may be defined by the professors / lecturers offering the excursion, dependent on the chosen destination / topic. They will be announced with the announcement of the excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

Content:
The research excursion deals with individual and specific topics from the respective study programmes. On an individual basis, professors and lecturerers from the rerspective study programme offer the research excursion to a topic or place of their choice.

A bullet point list with typically 10-12 entries will be provided by the professors and lecturers with the announcement of the research excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

Intended Learning Outcomes:
The excursion aims to support the scientific profile building of students and the acquisition of scientific, practical and social competencies. It supports the competence acquisition in other modules and / or the study programs in general. The students get practical insights into the topical field of the research excursion, deepen their comptencies in this field regarding ongoing research and its tranferability into practice.

In particular, the intended learning outcomes are the following:
- Select relevant scientific and practical information and recall it for visits of industries, organizations, cities and talks with experts and stakeholders,
- Prepare questions regarding the state-of-knowledge, open research questions and practical relevance and discuss these with fellow students,
- Discuss research and practical knowledge with stakeholders,
- Recognize the implementation of research and practical knowledge in the organisations / sites visited,
- Reflect on the state of implementation of theoretical knowledge in practice,
- Discuss with fellow students and supervisors gained insights and compare it with their expectations.

Teaching and Learning Methods:
The research excursion consists typically of the following elements (teaching and learning methods):
- Kick-off session: To achieve a good get-to-know, brief the students about the research excursion contents, related courses and required student performance an interactive in-presence workshop will be carried out. This covers prsentations, and interactive elements such as games, online-tools etc.
- Individual work and feedback: In order to prepare for the on-site visits the students carry out own (literature) research on the excursion topics. To document their learning progress and to be able to share the results they summarize their findings in written form. A presentation of the contents in front of the fellow students is an optional element. In this process, they are supervised, receive materials and continuous feedback.
- On-site visits: 3-5 day research trip with site-visits, presentations, discussions with stakeholders etc.This part will be specified in the specific program of the research excursion and can due to the variety of possible destinations and topics not be specified further at this point.
- Individual work: the students will reflect their learnings in written form.

Media:
Digital projector, board, flipchart, online contents, recent scientific journal publications, equipment and utilities demonstrating production processes in practice

Reading List:
Topic related reading, especially articles in international peer reviewed journals, will be provided during the course of the module.

Responsible for Module:
Prof. Cordt Zollfrank Prof. Hubert Röder Prof. Magnus Fröhling

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1632: Basics of Renewables Utilization | Grundlagen der stofflichen Biomassenutzung

Version of module description: Gültig ab summerterm 2019

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Assessment takes a written examination (60 minutes), with students recall structure, transformation and use of different renewable resources. Students are required to answer questions using individual formulations and outline structures and reactions. In addition, sample calculations are to be worked out.

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
Introduction to various kinds of constituents of renewable resources: sugars, polysaccharides, fatty acids and oils, amino acids, proteins, terpenes, aromatics. Their structure, composition, distribution, characteristics, analytics and kind of added value, as well as their use will be introduced.

Intended Learning Outcomes:
After completion of the modules, students understand the chemical composition of renewable resources as well as their production and application. Using this knowledge students are able to explain the respective advantages and disadvantages as well as analyze the underlying physical, chemical and biotechnological principles of their conversion into valuable products.

Teaching and Learning Methods:
In the lecture the teaching content is imparted by speech of the lecturer using powerpoint presentations and case studies. Corresponding to the teaching content exercise sheets are

prepared on which the students work in self-study. The solution and discussion of the exercises takes place in the tutorial.

Media:
Presentation, script, examples and solutions

Reading List:
script, sample solutions for exercises

Responsible for Module:
Rühmann, Broder; Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1947: Introduction to Electrochemistry | Einführung in die Elektrochemie

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Das Erreichen des Lernziels wird durch eine Klausur überprüft (Prüfungszeit: 60min). Auf die Note dieser schriftlichen Prüfung können bis zu 10% der Gesamtpunktzahl als Bonuspunkte angerechnet werden. Dabei legen die Ergebnisse der Onlinetests, die während des Semesters abgehalten werden, die Höhe der Bonuspunkte fest. Es müssen mindestens 65% der Punkte im Onlinetest erreicht werden, um Bonuspunkte zu erhalten. Dabei ist die Anhebung der Note von 4,3 oder schlechter auf 4,0 nicht möglich. Dies soll die Studierenden animieren kontinuierlich an den für sie sehr wichtigen Vorlesungen und Übungen teilzunehmen. Anhand von Fragen zu elektrochemischen Aspekten weisen die Studierenden nach, dass sie die entsprechenden Fachbegriffe, Bezeichnungen und Inhalte kennen, die grundlegenden Zusammenhänge verstanden haben und ihr Wissen über die ablaufenden Reaktionen im Rahmen der kinetischen und thermodynamischen Zusammenhänge anwenden können. Dazu werden konkrete rechnerische Aufgaben gestellt.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Erfolgreiche Teilnahme am Modul „Allgemeine Chemie“, „Physikalische Chemie“, „Mathematik“ und „Physik“ oder vergleichbare Kenntnisse.

Content:
- Konzepte der Elektrochemie: elektrochemische Thermodynamik (elektrochemisches Potential, Elektrodenpotential, Nernst Gleichung), Transport in Lösungen (Migration, Diffusion und Konvektion), Thermodynamik von Grenzflächen (die elektrochemische Doppelschicht), elektrochemische Kinetik.

- Aufbau einer elektrochemischen Messung und das Funktionsprinzip eines Potentiostats (Aufbau, Funktion und Anwendung).
- Stationäre Voltammetrie (Potentialsprung, lineare und zyklische Voltammetrie an Makro- und Mikroelektroden) für die Bestimmung von thermodynamischen und kinetischen Parametern.
- Mechanismen gekoppelter homogener Reaktion zur Energiekonversion und Elektrosynthese.
- Beispiele für die Anwendungen von Elektrochemie in realen Systemen (Gewinnung und Konversion erneuerbarer Energien, grüne Elektrosynthese).

Intended Learning Outcomes:
Die Studierenden erinnern das Basiswissen über fundamentale Konzepte der Elektrochemie und elektroanalytischen Chemie. Sie sind in der Lage, mit den generellen Prinzipien der Elektrochemie umzugehen und diese auf vereinfachte Probleme von realen elektrochemischen Systemen anzuwenden. Ein besonderer Fokus liegt hierbei auf dem Verständnis des allgemeinen und zeitlichen Zusammenspiels von Elektronentransfer, chemischen Reaktionen und Massentransport, welche die elektrochemische Antwort des Systems definieren. Des Weiteren sind die Studierenden vertraut mit industriell relevanten Prozessen und wie die Elektrochemie bei nachhaltiger Energiegewinnung und -speicherung helfen kann. Zusätzlich können sie die erlernte Theorie auf reale Beispiele aus Forschung und Industrie anwenden.

Teaching and Learning Methods:
In dieser Vorlesung werden die Lehrinhalte durch Vorträge des Dozenten anhand von Textdokumenten, PowerPoint-Präsentationen und Tafelbildern vermittelt. Dies ermöglicht eine detaillierte Darstellung des Lehrinhaltes und die Studierenden sind in der Lage Fragen zu stellen und zu diskutieren, sobald diese entstehen. PowerPoint Folien und Tafelbilder helfen als visuelle Unterstützung, um die komplexen Zusammenhänge in der Elektrochemie zu verstehen. Zusätzlich werden den Studierenden Übungsaufgaben zur Festigung des in der Vorlesung gelernten Inhaltes bereitgestellt. Die Lösungen dieser Übungsaufgaben werden später in einer Übungsstunde von den Studierenden präsentiert und diskutiert.

Media:
Präsentationen, Moodlekurs mit Onlinetests, Übungsblätter, Fragenkatalog, PowerPoint, Skript

Reading List:
Elektrochemie, Hamann/Vielstich, ISBN: 3527310681
Electrochemical Methods: Fundamentals and Applications; Bard/Faulkner, ISBN-13: 978-0471043720

Responsible for Module:
Prof. Nicolas Plumeré

Courses (Type of course, Weekly hours per semester), Instructor:
Einführung in die Elektrochemie (Übung) (Übung, 1 SWS)
Plumeré N [L], Höfer T

Einführung in die Elektrochemie (Übung) (Übung, 1 SWS)
Plumeré N [L], Höfer T

Einführung in die Elektrochemie (Vorlesung) (Vorlesung, 2 SWS)
Plumeré N [L], Plumeré N

Einführung in die Elektrochemie (Vorlesung) (Vorlesung, 2 SWS)
Plumeré N [L], Plumeré N
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1949: Protein Chemistry | Protein Chemistry [ProtCh]

Version of module description: Gültig ab summerterm 2022

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning results are proved in form of a written test (60 min exam duration). Based on questions to synthesis, purification, modification, analytics, characterisation and implementation of proteins the students prove that they know the corresponding technical terms, designations and contents, that they have understand the basic relations and are able to apply their knowledge. During the examination the tasks are set in both languages and the processing of the examination tasks can take place either in German or English.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful participation in the modules "Biochemistry" and "Practical course Biochemistry".

Content:
Basic principles of protein chemisty, chemical and biochemical protein synthesis, protein folding, amino acid analysis, posttranslational modifications, protein sequencing, prediction of secondary structures, tertiary structures, pI, determination of sulfylhydryl and disulfide groups, desalinisation, protein data bases, methods for protein immobilisation and labeling

Intended Learning Outcomes:
After sucessful completion of the module the students are able to describe and explain basic concepts, phenomenons and relations in the field of protein chemistry. The students can describe biological and chemical methods of protein synthesis, purification and modification of proteins and know how proteins can be characterised. In addition they can describe the impact of modifications on the protein structure or activity and apply their theoretical knowledge by means of questions.

Teaching and Learning Methods:
In the lecture the teaching content is imparted by speech of the lecturer using powerpoint presentations and blackboard sketches. Corresponding to the teaching content exercise sheets are prepared on which the students work in self-study. The solution and discussion of the exercises takes place in the tutorial.

Media:
Presentations, PowerPoint, script, exercise sheets

Reading List:
Bioanalytik, F. Lottspeich, H. Zorbas, Spektrum Akademischer Verlag
Voet, D. , Voet, J.G., Biochemistry 4th Edition, Wiley-VCH, 2011; Nelson, D.L, Cox, M.M., Lehninger Principles of Biochemistry 5th Edition, WH Freeman, 2008; Berg, J.M, Tymoczko, J.L., Stryer, L., Biochemistry 6th Edition, 2006

Responsible for Module:
Prof. Volker Sieber Ammar Al-Shameri

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1950: Biopolymers | Biopolymere [Biopol]

Version of module description: Gültig ab summerterm 2020

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning results are going to be proved in form of a written test (90 min). The students answer questions about biopolymers and their physicochemical properties. They prove that they have gained knowledge about the discrimination, classification and extraction of biopolymers within the scope of the module and are able to apply this knowledge. No additives are allowed.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic principles chemistry, physics and biology

Content:
The module deals with the structure and the function of polymers derived from nature (biopolymers). Covered are proteins, polysacharides, biogenic polyester, polyisoprenes and lignin. It is illustrated how bioploymers can be obtained from natural sources and which chemical reactions they are able to perform. Thereby the importance of the microstructure as well as the importance of the physicochemical properties in biological functions for the application-technical relevance of the biopolymers used as raw and functional material are covered.

Intended Learning Outcomes:
By attending the module the students are able to discriminate biopolymers and to classify them application-oriented. They know how and from which natural sources biopolymers can be obtained. The students acquire basic knowledge in the understanding of biopolymers and their physicochemical properties and can describe these properties and compare them among each other. Thereby they are able to differentiate suitable biopolymers application-oriented.

Teaching and Learning Methods:
Teaching methods: in the lecture the technical contents are communicated by a talk of the lecturer, supported by PowerPoint and skectches on the blackboard. In relation to the teaching content written tasks are disbursed on which the students work in self-study before the tutorials. The solution and discussion of the tasks as well as the visulaization of the teaching content by working with molecular models takes place in the tutorials. Learning methods: at the postprocessing of the lecture exspcecially while the exercises are solved the students keep themselves intensive busy with the teaching contents of the lecture and reach in this way a comprehensive knowlegde about biopolymers.

Media:
Lecture, blackboard sketch, foil script, molecular models

Reading List:
Türk, Oliver: Stoffliche Nutzung nachwachsender Rohstoffe
Grundlagen - Werkstoffe - Anwendungen, Springer Verlag

Responsible for Module:
Zollfrank, Cordt; Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Biopolymere (Vorlesung) (Vorlesung, 2 SWS)
Zollfrank C [L], Zollfrank C

Biopolymere (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Zollfrank C
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1954: Fluid Mechanics | Strömungsmechanik

Version of module description: Gültig ab summerterm 2021

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module will be assessed by a written examination. Students calculate tasks of fluidmechanics based on its fundamental equations. In addition, the unterstanding of content is tested by the explanation of theoretical operations. Dimensionless numbers to evaluate complex task are applied and explained. Altogether the students show that they can solve known tasks from the fluid mechanics area and transfer their acquired knowledge to new assignments of tasks. Exam duration: 90 minutes.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of the most important physical correlations (basic parameters with units, definition of pressure, temperature etc.) must be available. Besides formation and solution of systems of equations as well as command of simple integral and differential calculus as well as Physics and Mathematics is a requirement.

Content:
This module provides basics of fluid mechanics, that are relevant for further engineering applications . Therefore the theoretical fundamentals are derived and deepened throug illustrating examples . The content will cover the following topics: hydrostatics, fluid dynamics (Bernoulli , Navier-Stokes , flow resistance), CFD.

Intended Learning Outcomes:
After participating in the module, students are able to understand and analyze simple tasks regarding flows, to apply the methods for their solution and to give a mathematical solution. In particular the students can transfer the learned methodology and the obtained results to new assignments of tasks.

Teaching and Learning Methods:
The module consists of a lecture during which also exercises will be performed alternately. Contents of the lecture shall be imparted in speech and by presentation. To deepen their knowledge students shall be encouraged to study the literature and examine with regards to content the topics. In the exercises performed as part of the module learned theory shall directly be applied with a practical orientation by means of arithmetic examples.

Media:
Presentations, slide scripts, exercises

Reading List:
Siekmann, Thamsen: Strömungslehre, 2. Auflage, Springer
Örtel: Strömungsmechanik für Ingenieure und Naturwissenschaftler, 7. Auflage, Springer
[226] Baehr, Hans Dieter; Kabelac, Stephan: Thermodynamik, 14. Auflage, Springer, ISBN 978-3-642-00555-8, 2009
[242] VDI Wärmeatlas, VDI-Gesellschaft Verfahrenstechnik und Chemie-Ingenieurwesen 9.Auflage, Springer-Verlag ISBN 3-540-41201-8 9.Auflage

Responsible for Module:
Gaderer, Matthias; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Strömungsmechanik (Übung) (Übung, 2 SWS)
Gaderer M [L], Huber B

Strömungsmechanik (Vorlesung) (Vorlesung, 2 SWS)
Gaderer M [L], Huber B
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1955: Heat transfer | Wärmeübertragung

Version of module description: Gültig ab summerterm 2021

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Exam achievement shall be done in the form of a written test. The students calculate heat transfer tasks. They are able to explain dimensionless quantities and apply them in arithmetic examples. They explain and calculate different mechanisms of heat transfer. Altogether the students show that they are able to understand and solve assignments of tasks from the heat transfer area.
Exam duration: 90 minutes.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of the most important physical correlations (basic parameters with units, definition of pressure, temperature etc.) must be available. Besides formation and solution of systems of equations as well as command of simple integral and differential calculus is a requirement.
Physics, Mathematics and Thermodynamics

Content:
In this module knowledge in heat transfer gained from the lecture of Technical Thermodynamics (TTD) shall be extended, deepened computation bases are created and dimensionless numbers are deduced. Topics will be: heat conduction, covection, heat radiation, heat transfer through objects, calculations based on Nusselt and Prandtl number, dimensioning and calculation of heat exchangers, transient heat conduction, influence of phase changes and knowledge transfer on parallel issues in mass transfer.

Intended Learning Outcomes:
After having participated in the module the students are capable of understanding and analysing simple tasks relating to heat transfer (convection, conduction, radiation). Additionaly the student will be able to apply methods to solve problems concerning heat transfer systems.

Teaching and Learning Methods:
The module consists of a lecture during which also exercises will be performed alternately. Contents of the lecture shall be imparted in speech and by presentation. To deepen their knowledge students shall be encouraged to study the literature and examine with regards to content the topics. In the exercises performed as part of the module learned theory shall directly be applied with a practical orientation by means of arithmetic examples. Thus for instance the construction of a heat exchanger is outlined.

Media:
Presentations, slide scripts, exercises

Reading List:
[224] Stephan, P.; Schaber, K.; Stephan, K.; Mayinger, F.: Thermodynamik, Band 1: Einstoffsysteme, 17. Auflage, Springer, ISBN 978-3-540-70813, 2006
[226] Baehr, Hans Dieter; Kabelac, Stephan: Thermodynamik, 14. Auflage, Springer, ISBN 978-3-642-00555-8, 2009
[] Wärme- und Stoffübertragung, Hans Dieter Baehr und Karl Stephan, Springer, ISBN 978-3-642-36558-4 , 2013
[227] HSC Chemistry, Outokumpu Research Oy, Pori, Finnland, A. Roine, Ver. 1.10, 1990
[233] Stephan, P.; Schaber, K.; Stephan, K.; Mayinger, F.: Thermodynamik Grundlagen und technische Anwendungen, Band 2: Mehrstoffsysteme und chemische Reaktionen, 15. Auflage, Springer, ISBN 978-3-540-36709-3, 2010
[234] Gmehlin, J.; Kolbe, B.: Thermodynamik, 2. Auflge, VCH, ISBN 3-527-28547-4, 1992
[235] Atkins, Peter W.: Physikalische Chemie, VCH, ISBN 3-527-25913-9, 1990
[268] GTT-Technologies; Programm Factsage 6.3, http://www.gtt-technologies.de
[242] VDI Wärmeatlas, VDI-Gesellschaft Verfahrenstechnik und Chemie-Ingenieurwesen 9.Auflage, Springer-Verlag ISBN 3-540-41201-8 9.Auflage

Responsible for Module:
Matthias Gaderer (gaderer@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1978: Green Chemistry | Green Chemistry

Version of module description: Gültig ab winterterm 2021/22

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The achievement of the learning outcomes will be tested in a written exam and in a seminar. The students are expected to be able to reproduce the course contents correctly and transfer them to different contexts in written form.
The written exam has a duration of 90 minutes. Aids are not permitted. In addition, the contents of the course will be enhanced in a seminar. The proportion of the written exam to the module grade is 80 %. In the seminar, students analyze selected case studies from current literature in the context of Green Chemistry with respect to their sustainability and present these to their co-students and instructor in an oral presentation with short discussion and a brief written composition. The proportion of the seminar grade to the module grade is 20 %.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basics of chemistry, physics and biology

Content:
The module contains an introduction to the basics of environment-friendly 'green' synthesis routes for chemical products. The 12 basic principles of 'green engineering' will be covered. Sustainably production and treatment, process optimizations and innovative technological approaches and optimized separation methods will be discussed. The different processes will be presented with respect to relevant environment aspects, sustainability and energy- as well as raw materials consumption.

Intended Learning Outcomes:
After completion of the module, the students are able to describe the basic principles of environment-friendly and sustainable production of chemicals and demonstrate them at the

examples of selected process chains. They can determine and present specific resource requirements with respect to energy, raw- and auxiliary materials as well as the yields during production, emissions into air, water and soil, as well as amounts of wastewater and solid waste. They are alse able to couple syntheses to preceding and subsequent processing steps. Thus, they can assess the sustainabilities of production processes autonomously.

Teaching and Learning Methods:
Lecture with blackboard and slide presentations for the development of technical concepts. Seminar with written tests. Self-study is essential to consolidate the course contents.

Media:
Lecture, blackboard, slides, group work

Reading List:
Jiménez-González, Constable, Green Chemistry and Engineering, Wiley-VCH, 2010

Responsible for Module:
Prof. Herbert Riepl

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Interdisciplinary Electives | Fachübergreifende Wahlmodule

Module Description

CS0063: Microeconomics | Microeconomics [Micro I]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the exam (written, 120 minutes) students should demonstrate their ability to adequately interpret the microeconomic concepts and apply the methods worked on in class. By means of multiple-choice-questions, which are either embedded in a context/case/scenario or require prior computation, students' capacity to apply the learned solution strategies to new settings and draw correct economic implications is assessed. A non-programmable calculator is allowed.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:

Content:
This course provides an introduction to basic concepts of microeconomics. To understand how a transition towards a more sustainable economy is possible we first have to understand the basic mechanisms in the economy. To this end, this lecture investigates the behavior of individual economic units, such as households, business firms, and public institutions. Another concern is how these units interact to form markets and industries. How can consumer decisions be explained and how can aggregate demand be derived from consumer choice? Which are the factors that determine the production decisions of companies? How do equilibrium prices emerge in competitive markets, how in monopoly markets? What is the effect of government interventions in markets (e.g. green taxes, price controls)? How does market power affect social welfare? Which factors lead to market failure?

Intended Learning Outcomes:
After attending this module, students will be able to describe economic tradeoffs (particularly in choice under scarcity situations of consumers and firms). Moreover, they know strategies to solve those tradeoffs and are capable of applying them to new situations. Students are able to explain the fundamental economic mechanisms underlying specialisation and trade (particularly in view of technological progress). Students can predict how government interventions (e.g. carbon taxes, price controls) will affect simple competitive markets. They are able to explain why certain industries are prone to market concentration and how market power affects social welfare. They can distinguish which types of goods are efficiently provided on free markets and which not.

Teaching and Learning Methods:
An interactive lecture introduces essential microeconomic concepts and theories and illustrates them with the help of topical empirical examples. Classroom experiments complement the classic bird-eye's perspective by nudging students to put themselves in the positition of particular economic players, thereby requiring them to actively reflect the concepts introduced. Online surveys at the end of each chapter enable students to select which topics they would like to intensify in subsequent classes. In the accompaying exercise class, students practice, on specific problems and examples, the mathematical techniques needed to develop a deeper understanding of the economic concepts. In self-study students use the textbook to repeat the concepts introduced in class and apply them to additional examples.

Media:
Textbook, slides, exercise sheets, classroom experiments, online surveys

Reading List:
Robert S. Pindyck and David L. Rubinfeld, Microeconomics, 8th Edition, Pearson, 2013 (ISBN 13: 978-0-13-285712-3). AND Robert S. Pindyck und David L. Rubinfeld, Mikroökonomie, 8. Aufl., Pearson Studium, 2013 (ISBN-13: 978-3868941678).

Responsible for Module:
Goerg, Sebastian; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Economics I am Campus Straubing (Microeconomics) (Vorlesung, 2 SWS)
Goerg S [L], Goerg S

Economics I - Übung am Campus Straubing (Übung, 2 SWS)
Goerg S [L], Speckner M
For further information in this module, please click campus.tum.de or here.

Module Description

CS0067: Macroeconomics | Macroeconomics [Macro I]

Version of module description: Gültig ab winterterm 2021/22

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The exam will be a written test (120 min.) at the end of the term. The exam is designed to assess the participants' capabilities to apply macroeconomic theory in order to discuss and solve real world problems of the economy as a whole. Participants should demonstrate their capacity for abstraction (thinking in economic models), concretization (calculating, interpreting and applying the results of the model, mathematical processing as well as graphical illustration.

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
This module provides an introduction to basic concepts of macroeconomics. It covers:
- key institutions of capitalism as an economic system (private property, firms, markets)
- technological change as a trigger for economic growth
- price-taking and competitive markets
- price-setting, rent-seeking and market disequilibuium
- market successes and failures
- markets, contracts and information
- credit, banks and money
- economic fluctuations and unemployment
- unemployment, inflation, fiscal and monetary policy
- technological progress and living standards
- the Great Depression, the golden age of capitalism and the global financial crisis

Intended Learning Outcomes:
After attending the module, students will able to describe the composition and distribution of the Gross Domestic Product. They can analyze the economic mechanisms underlying unemployment as well as issues regarding monetary policy and inflation. Further, participants will learn to understand the economic crisis and the wealth differences among nations. Students are enabled to think in models and apply mathematical solutions when approaching economic problems.

Teaching and Learning Methods:
The module consists of a lecture and an exercise course. The lecture content will be delivered in a verbal presentation with the help of slides. Since the foundation of the lecture is a textbook including recent economic history, the teaching is full of real life examples. The content of the lecture is put into practice in the exercise course which applies the theoretical knowledge by basic mathematical calculations and graphical illustrations. Therefore, the module aims at encouraging participants to independently think about economic problems discussed in the lecture and in the current literature. Students are enabled to use the instruments (abstract and model thinking) for operationalizing economic problems and solve them in the conventional, mathematical manner.

This module is also offered at TUM Campus Straubing.

Media:
http://www.core-econ.org/

Reading List:
The CORE Project (2016): 'The Economy', in: Azm Premji University, Friends Provident Foundation, HM Treasury, Institute for New Economic Thinking, Open Society Foundations, SciencesPo, UCL (eds.), University College London.

Responsible for Module:
Pondorfer, Andreas; Prof. Dr.sc.pol.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0071: Material Flow Analysis and Life Cycle Assessment | Material Flow Analysis and Life Cycle Assessment [MFA&LCA]

Version of module description: Gültig ab summerterm 2024

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Large courses of approx. more than 60 students: Written exam (90 minutes):
Students have to solve basic problems from the MFA, and LCA field. They have to demonstrate that they can analyze systems from a system and life cycle perspective. They have to prove their ability to use the correct terminology. In particular, they need to prove their ability to analyze and model material and energy flows, to determine and apply data, to assess environmental impacts, and to consider uncertainties. In addition they have to demonstrate their ability to interpret MFA and LCA study results and discuss the importance and applicability of the methods in practice.
Learning aids: pocket calculator.

Small to medium sized courses with up to approx. 60 students:
The students demonstrate the above-mentioned capabilities through group work. In groups of 3-5 students they receive case-based problems of material flow analysis and/or life cycle assessment. They have to solve these using the competencies obtained in the course. The results have to be presented and discussed (ca. 20') as well as documented in a report (ca. 20 pages). The individual contributions in both, presentation and report have to be specified.

The form of examination will be announced in class and on the learning platform in the second lecture week of the semester at the latest.

Voluntarily, students have the opportunity to increase their grade by up to 0.3 through extra work in form of individual assignments (hand-in and or presentation). The students either have to discuss a case study or a scientific paper or solve a problem from the topical scope of the lecture. They have to summarize their results in a 10' presentation + discussion or a 2-3 page report. Full mark for the course is obatainable without this voluntary work.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
• Introduction to systems and life cycle thinking
• The four phases of life cycle assessment
o Goal and scope definition
o Life cycle inventory analysis (LCI)
o Life cycle impact assessment (LCIA)
o Interpretation
• Material flow analysis
o Method of material flow analysis
o Material flow networks
o Determination of mass flows and stocks
o Material flow modelling
• Software systems and databases for material flow analysis and life cycle assessment
• Uncertainties and their handling
• Current trends and developments in material flow analysis and life cycle assessment
• Case studies

Intended Learning Outcomes:
At the end of the module students
• define key terms of material flow analysis and life cycle assessment
• explain the concepts of material flow analysis, life cycle assessment and systems analysis regarding their procedures and their theoretical backgrounds
to understand how to apply material flow analysis and life cycle perspective to various contexts and systems in order to assess their environmental performance
• gather necessary information, to choose suitable methods, and to apply these for simple MFA and LCA studies
• carry out simple MFA and LCA calculations by investigating underlying resource and energy flows associated with processes
• interpret MFA and LCA study results
• discuss the importance and applicability of the methods in practice

Teaching and Learning Methods:
Format: lecture and exercises to introduce the content, to repeat and deepen the understanding as well as practice individually and in groups. Some tutorials will be carried out computer-based.

Teaching / learning methods:
• Media-assisted presentations
• Group work/case studies

• Individual tasks
• Reading
• Computer lab exercises using MFA and LCA software systems

Media:
Digital projector, board, flipchart, online contents, videos, case studies, computer lab

Reading List:
• Baccini, P. & Brunner, P.H. (2012): Metabolism of the Anthroposphere: Analysis, Evaluation, Design. MIT Press.
• Brunner, P.H. & Rechberger, H. (2016): Handbook of Material Flow Analysis: For Environmental, Resource, and Waste Engineers. CRC Press.
• Curran, M.A. (2015): Life Cycle Assessment Student Handbook, Scrivener Publishing.
• Fröhling, M.; Hiete, M. (2020): Sustainability and Life Cycle Assessment in Industrial Biotechnology. Springer, Cham.
• Guinée, J.B. (2002): Handbook on life cycle assessment: operational guide to the ISO standards. Kluwer, Dordrecht.
• Hauschild, M.Z. & Huijbregts, M.A.J. (2015): Life Cycle Impact Assessment (LCA Compendium - The Complete World of Life Cycle Assessment), Springer, Cham.
• Hauschild, M.; Rosenbaum, R.K.; Olsen, S.I. (2018): Life Cycle Assessment: Theory and Practice. Springer, Cham.
• Jolliet, O., Saade-Sbeih, M. (2015): Environmental Life Cycle Assessment. CRC Press.
• Klöpffer, W. & Grahl, B. (2014): Life Cycle Assessment (LCA), Wiley-VCH.

Responsible for Module:
Fröhling, Magnus; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0075: Management Science | Management Science [ManSci]

Version of module description: Gültig ab winterterm 2024/25

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students mastery of the content taught in this module is checked with a 60 minutes written and multiple-choice exam. In the written part of the exam students have to answer questions, apply algorithms to solve problems, create mathematical models for small example problems, and discuss presented results. By this, the students have to demonstrate that they have understood and can apply the mathematical models and methods to solve business planning problems. The multiple-choice questions allow to check if students also understood other parts of the lecture that could not be included in the written part. This will be used to assess if fundamental aspects in Management Science can be evaluated. The overall grade of the module is based on the result obtained in the written and multiple-choice exam. Students are only allowed to use a non-programmable calculator.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Knowledge of Mathematics and Statistics at the level as definend in the German Abitur

Content:
Management Science is about modelling, solving and analysing planning and decision problems using mathematical concepts. Management Science is used across different industries, departments and organizations. The lecture will treat the Management Science approach to decision making in general and the following topics in particular: Linear Programming, Mixed-Integer Programming, Graph Theory, Network Flow, Dynamic Programming and Decision Theory.

Intended Learning Outcomes:
After successful completion of the module, students are capable of modelling planning problems. They are able to solve small business problems manually by using models and methods of linear

and integer programming, of graph theory, of network flow, of dynamic programming, and of decision theory.

Teaching and Learning Methods:
The module consists of a lecture and exercise courses, which are provided weekly, as well as a voluntary tutorial offered. In the lecture, the content is jointly developed with the students mainly by using slides. The exercise course repeats parts of the lecture contents by using examples. The tutorials are delivered by student teaching assistants for smaller groups which gives the student the opportunity to pose questions and receive immediately help from the teaching assistant.

Media:
Script, Presentation slides

Reading List:
Bradley, S.P., A.C. Hax und T.L. Magnanti: Applied Mathematical Programming, Addison-Wesley, 1977.
Domschke W and A. Drexl: Einführung in Operations Research, 9th Ed., Springer, 2015.
Hillier FS and Lieberman GJ: Introduction to Operations Research, 9th ed., McGraw-Hill, 2010.
Winston WL: Operations Research, 5th Ed., Thomson, 2004.

Responsible for Module:
Hübner, Alexander; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Management Science Lecture - Campus Straubing (Vorlesung, 2 SWS)
Hübner A [L], Schäfer F

Management Science Exercise - Campus Straubing (Übung, 2 SWS)
Hübner A [L], Schäfer F
For further information in this module, please click campus.tum.de or here.

Module Description

CS0193: Foundations of Sustainable, Entrepreneurial & Ethical Business | Foundations of Sustainable, Entrepreneurial & Ethical Business

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination performance will be in the form of a written exam (120 minutes). The written exam provides a comprehensive assessment of whether students know and understand the basic principles of entrepreneurship and sustainability. They answer questions about the concepts that explain the mindset of entrepreneurial individuals and the management of entrepreneurial firms. They also answer questions about basic definitions of specific types of entrepreneurship and entrepreneurial behavior related to environmental and social problems. In addition, students will be assessed on their knowledge of basic principles and models of ethical economic behavior and their ability to use and develop knowledge of entrepreneurship. They answer questions on basic definitions and theories of ethical behavior and evaluate ethical behavior in an economic context.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:

Content:
The module introduces students into basic principles of the topic of entrepreneurship from a global and sustainability perspective. Students will be equipped with basic knowledge on:
- definitions, regional aspects, and special forms of entrepreneurship
- understanding of ecological and social problems and entrepreneurial approaches to solving them
- entrepreneurial individuals, including their personality, creativity, idea development, cognition, opportunity recognition, decision making, affect, and moving forward from failure
- entrepreneurial firms, including their growth strategies, strategic alliances, and resources.

Beyond that, students will engage in break-out group workshops to personally experience the process of opportunity recognition and development. In these workshops, teams apply concepts from the academic literature to real-world business issues to solve environmental and/or social problems. Furthermore, students give presentations to the audience and discuss their results.
In addition, the module introduces basic problems, arguments, and theoretical approaches of business ethics. It investigates the chances of realizing moral norms at the interception of entrepreneurship/economics and ethics. Basic is the analysis of ethical decision processes in corporations and the detailed investigation of situations and alternatives of action. Topics involve reputation, trust and social capital as well as corruption, environmental protection, and global ethical concepts. This part ends with a critical discussion of different research approaches in the debate on business ethics.

Intended Learning Outcomes:
Students know basic concepts of entrepreneurship and sustainability including basic definitions, psychological processes and characteristics of entrepreneurs as well as possible development paths of entrepreneurial firms and are able to explain them. Furthermore, students transform and apply this knowledge to real cases. They are able to find entrepreneurial solutions for ecological and/or social problems in real cases, taking into account the theories of entrepreneurial processes.

Furthermore, students understand the ethical significance of economic theories, reflect on ethical aspects in economics and apply ethical theories in an economic, social and ecological context. Students are able to draw conclusions from the known theories and concepts and to behave ethically in everyday business life.

Teaching and Learning Methods:
The module combines several learning methods.
- The basic knowledge as well as real world examples will be provided through the lecture.
- Discussions in the lecture and active participation are encouraged and will contribute to deepen the understanding of the concepts introduced.
- Workshops in smaller groups enable the students to apply (part of) their theoretical knowledge to real-world problems. This format additionally fosters creativity and team work.
- Students will get additional background knowledge from the scientific literature in private reading.

Media:
Presentations and PowerPoint slides

Reading List:
Hisrich, R. D., Peters, M. P., & Shepherd, D. A. (2010). Entrepreneurship (8th ed.). New York: McGraw-Hill.
Read, S., Sarasvathy, S., Dew, N., Wiltbank, R. & Ohlsson, A.-V. (2010). Effectual Entrepreneurship. New York: Routledge Chapman & Hall.
Lütge, C., Uhl, M. (2018). Wirtschaftsethik. München: Vahlen.
Crane, A., Matten, D., Glozer, S., Spence, L. (2019): Business Ethics. Oxford: Oxford University Press

Responsible for Module:
Prof. Claudia Doblinger

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Entrepreneurship (Vorlesung, 2 SWS)
Doblinger C [L], Doblinger C, Fischer D

Introduction to Business Ethics (Vorlesung, 2 SWS)
Doblinger C [L], Krinner S
For further information in this module, please click campus.tum.de or here.

Module Description

CS0196: Sustainable Operations | Sustainable Operations

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination consists of a written exam (90 min.). Permitted tool is a non-programmable calculator.
In the written exam, students demonstrate that they can apply various approaches to problem solving, building on their understanding of production and logistics planning in general. Using exemplary tasks from production or logistics planning, students demonstrate that they can interpret planning problems as well as relationships between different problems. Based on this, students will provide recommendations for a solution to these problems.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Fundamentals of Mathematics and Management Science are recommended

Content:
This is a basic module in which an overview of planning problems in production and logistics and methodologies for solving them will be developed. Students are familiarized with different levels of planning hierarchy (strategic, tactical, operational) and the planning problems at each level. Heuristics and additionally simple models of linear and mixed-integer programming are discussed and applied as methodologies for solving the planning problems in the area of production and in the area of logistics. The module includes these parts, among others:
- Strategic planning problems: e.g. location planning
- Tactical planning: designing the infrastructure of different production systems (workshop production, flow production, production centers)
- Operational planning problems: Demand forecasting models, main production program planning
- Material requirements planning

- Resource scheduling and control: lot size planning, machine scheduling planning, line-up sequences for flow production
- Transportation logistics: planning problems for determining tours, routes and packing schemes
- Material logistics: policies for inventory management and their extension to stochastic demands; strategic design of the logistics network; interfaces with predecessor or successor companies
- Procurement logistics: methods for the selection of suppliers
- Distribution logistics: setting up a suitable supply network; processes in the warehouse

Intended Learning Outcomes:
After participating in this basic module, students are able to understand interrelationships between various planning problems in production and logistics. Analyze selected planning problems of the strategic, tactical and operational level (for details see learning content) and apply potential solutions to manage them. In doing so, the students know essential management tasks in production and logistics planning and learn to evaluate the economic and sustainability-relevant significance of production and logistics-related decisions (e.g. the trade-off between inventory and setup costs or between costs, service and environmental protection).

Teaching and Learning Methods:
The learning methods include lectures, tutorials and in-depth literature. The lectures serve to teach theoretical basics including the completion of exercises. The tutorials accompanying the lectures deepen the contents of the lectures in smaller groups and include calculation of exercises mainly in individual work, partly also in group work. Literature for in-depth study will be announced and recommended in the lecture.

Media:
Presentations, Script

Reading List:
Günther, H.O., Tempelmeier, H. (2020), Supply Chain Analytics
Ghiani, G., Laporte, G., Musmanno R. (2013), Introduction to Logistics Systems Management, 2. Aufl., Wiley

Responsible for Module:
Prof. Alexander Hübner

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0259: Communication and Presentation | Kommunikation und Präsentation

Version of module description: Gültig ab winterterm 2022/23

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the course of the semester elaboration of presentations (individual and group presentations, role play, case processing in the group, video analyses) shall be expected (non-graded) as an exam achievement by the students. The module shall be terminated by a written test (90 min). In this exam the students shall convey different models from communications psychology without tools or illustrate them by using different mentioned scenarios.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
The module of Communication and Presentation is divided into the following fields:

• Basics of communications and communication methodology
• Communication rules nd their application in daily professional life
• Axioms of communications
• The four levels of communications ('four-ear-model')
• Communications in groups
• Giving and taking constructive feedback
• Do´s and Don´ts of communications
• Advantageous basic attitudes and communication techniques of non-directive conversation guidance

Intended Learning Outcomes:
After having participated in the module the students are able to understand basic communication models and allocate underlying theory to models accordingly.
Furthermore the students are able to describe communication by using case studies.
The four-level model of communications may be used in everyday life and in professional life.
When communicating in groups the students may give and take constructive feedback.

Teaching and Learning Methods:
During the lecture a speech (including discussion) will be worked out by the students. During the exercises role plays, case studies will be performed. In video analyses individual and group presentations shall be performed and analysed.

Media:
Presentations, script, video, exercise sheets, flipchart, powerpoint, showing films

Reading List:
Schulz von Thun, F. (2014). Miteinander reden 1: Störungen und Klärungen. Allgemeine Psychologie der Kommunikation. Hamburg: Rowohlt Verlag.
Schulz von Thun, F. (2014). Miteinander reden 2: Stile, Werte und Persönlichkeitsentwicklung. Differentielle Psychologie der Kommunikation. Hamburg: Rowohlt Verlag.
Schulz von Thun, F. (2014). Miteinander reden 3: Das "Innere Team" und situationsgerechte Kommunikation. Hamburg: Rowohlt Verlag.
Schulz von Thun, F. (2014). Miteinander reden 4: Fragen und Antworten. Hamburg: Rowohlt Verlag.

Responsible for Module:
Claudia Martin (martin.cm@t-online.de)

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0272: Experimental Lab - Architecture, Science & Design | Experimental Lab - Architektur, Wissenschaft & Design

Version of module description: Gültig ab winterterm 2024/25

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Im Laufe des Semesters wird von den Studierenden die Ausarbeitung praxisorientierter Übungen sowie eine Studentische Projektarbeit erwartet. Mit den Übungen soll das Verständnis für Gestaltung und Design im Kontext zu wissenschaftlichen Themen dargelegt und erläutert werden. Bei der Projektarbeit erarbeiten die Studierenden in kleinen Teams eigene Ideen im öffentlichen Stadtraum. Als Prüfungsgesamtleistung werden die Übungen als Einzelarbeit und eine abschließende Präsentation der Projektarbeit in Teamarbeit bewertet. Die Idee, Funktion, Kontext, kreative Ausarbeitung der Konzepte und die Art der Präsentation gehen in die Bewertung mit ein.

Prüfungsart: mündlich (Präsentation); Prüfungsdauer: 30 Minuten

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
Der Inhalt dieses Moduls ist in drei Schwerpunkte gegliedert: Der erste Schwerpunkt ist eine Einführung und ein gemeinsamer „Mind Opening“ Workshop im Spannungsfeld von Wissenschaft, Design und Architektur. Zudem werden den Studierenden Grundlagen Visueller Kommunikation vermittelt, die ihnen künftig bei der Umsetzung eigener Präsentationen dienen sollen. Es ist ein Gastvortrag über „Interdisziplinäre Zukunftsthemen“ geplant.

Ein weiterer Schwerpunkt umfasst die Vermittlung grundlegender Kenntnisse im Bereich Kunst, Design und Architektur an die Studierenden. Dies geschieht in Form von Vorträgen sowie praktischen, experimentellen Übungen mit verschiedensten Materialien natürlichen Ursprungs

(Nachwachsenden Rohstoffen). Dabei wird auf deren komplexe Wahrnehmung im privaten als auch öffentlichen Raum eingegangen und die große Bandbreite möglicher Anwendungen thematisiert. Es soll die Kreativität der Studierenden angeregt werden, Wissenschaft & Forschung in den Kontext weiterer Themenbereiche zu stellen. Dieser Synergieeffekt soll innovative Denkansätze anstoßen und neue Spannungs- und Forschungsfelder eröffnen.

Der dritte Schwerpunkt ist die Umsetzung der erlernten Methoden und Ansätze in einem eigenen studentischen Projekt im öffentlichen Raum, in dem die vielfältigen Nutzungsmöglichkeiten von Nachwachsenden Rohstoffen erfahrbar gemacht werden sollen. Die Kommunikation über die gewonnenen Erfahrungen und Ergebnisse innerhalb des Kurses sowie gegenüber der Öffentlichkeit sind weiterer, zentraler Bestandteil des Moduls. Es sollen die Präsentationsfähigkeiten der Studierenden für die Umsetzung ihrer eigenen Ideen gefördert werden.

Intended Learning Outcomes:
Nach der Teilnahme an dem Modul sind die Studierenden in der Lage, Grundlagen und Methoden von Gestaltung und Design zu verstehen und diese auf Produkte aus Nachwachsenden Rohstoffen anzuwenden. Dabei können die Studierenden die speziellen Anforderungen und Notwendigkeiten, die sich aus der Verwendung natürlicher Materialien ergeben, ermitteln und in Lösungen umsetzen. Die in den Übungen und aus der Projektarbeit gewonnenen Erfahrungen erlauben es den Studierenden, kreative Lösungen mit Nachwachsenden Rohstoffen zu erfassen und diese zu demonstrieren. Mit den erworbenen Kenntnissen aus der Projektarbeit können sie mit verschiedenen Techniken, die sie aus der eigenen Kreativität transferieren, Präsentationen ansprechend planen und selbständig vortragen.

Teaching and Learning Methods:
In kleinen Teams realisieren und präsentieren die Studierenden Übungen und eine Projektarbeit zu einem bestimmten Thema. Die Ergebnisse werden innerhalb des Kurses und/oder im öffentlichen Raum vorgestellt.
Weitere Methoden sind Vorträge zu den Themen Kunst, Design & Architektur; themenbezogene, experimentelle Übungen; ein Gastvortrag; eine Exkursion und/oder Ausstellung; Projektarbeit in Teams mit konstruktivem, gegenseitigem Austausch und abschließender Präsentation

Media:
Nutzung aller verfügbaren multimedialen Möglichkeiten

Terminplan, Präsentationsfolien, Übungsaufgaben werden den Studierenden digital zu Beginn des Semesters zur Verfügung gestellt.

Reading List:
Die aktuellsten Literaturempfehlungen werden den Studierenden zu Beginn des Semesters bei der Einführung in das Modul zur Verfügung gestellt.

Responsible for Module:
Verena Stierstorfer

Courses (Type of course, Weekly hours per semester), Instructor:
Spannungsfeld Architektur, Wissenschaft & Design; begleitende Übungen (Vorlesung mit integrierten Übungen, 1 SWS)
Stierstorfer V [L], Stierstorfer V

Experimental Lab - Projektarbeit (Projekt, 2 SWS)
Stierstorfer V [L], Stierstorfer V

Spannungsfeld Architektur, Wissenschaft & Design (Vorlesung, 1 SWS)
Stierstorfer V [L], Stierstorfer V
For further information in this module, please click campus.tum.de or here.

Module Description

ED0180: Philosophy and Social Sciences of Technology | Philosophie und Sozialwissenschaft der Technik

Version of module description: Gültig ab summerterm 2011

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Prüfungsdauer (in min.): semesterbegleitende Online-Aufgaben.
Studienleistungen - Besuch der Vorlesung im Umfang von 2 SWS (2 SWS = 1 CP); - Lektüre von Texten (30 h = 1 CP); - Bearbeitung der drei Onlineaufgaben (30 h = 1 CP) Das Semester begeleitend werden drei schriftliche Aufgaben zu Teilabschnitten des Vorlesungsinhaltes gestellt, die individuell zu bearbeiten sind. Die Aufgabenstellung erfolgt online. Bearbeitungszeit ist jeweils 7 Tage. Die Ergebnisse der Online-Aufgaben werden über TUMonline bekannt gegeben. Die Prüfungsnote wird aus den Ergebnissen der drei Online-Aufgaben gebildet. Eine Wiederholung in Form einer mündlichen Prüfung ist möglich; Voraussetzung hierfür ist die vorangehende Beteiligung an den Online-Aufgaben. Bei Nichtbestehen der Nachprüfung ist das gesamte Modul zu wiederholen.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
keine

Content:
In dieser Vorlesung werden philosphische und sozialwissenschaftliche Perspektiven zur Betrachtung und Beurteilung von Technik erarbeitet. Es wird untersucht, welche politischen, soziologischen und ökonomischen Dimensionen moderner Technik unser Leben mitbestimmen und wie soziale
Faktoren in die Gestaltung von Technik eingehen.

Intended Learning Outcomes:
Ziel der Veranstaltung ist es, jenseits natur- und ingenieurwisenschaftlicher Spezialisierung ein umfassendes Bild von den Wirkungsformen und den meist nur stillschweigend mitgedachten, gesellschaftlichen Funktionsvoraussetzungen moderner Technik zu vermitteln.

Teaching and Learning Methods:
mit medialer Unterstützung

Media:
elektronische Vorlesungsskripte, Präsentationen

Reading List:
Je spezifisch zu den einzelnen Vorlesungswochen im Skript angegeben.

Responsible for Module:
Ulrich Wengenroth (ulrich.wengenroth@mytum.de)

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1609: Scientific Working | Wissenschaftliches Arbeiten

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Concepts of scientific working shall be practically applied and deepened by the preparation of homework. Homework shall be done as an academic performance and shall not be integrated into the overall performance. Teamwork is possible here. Exam achievement shall be done by a written test. In this test students shall prove that they are familiar with the rules of good scientific working, that they master a methodological approach to planning, execution, evaluation and discussion of a scientific work and that they are able to take a very critical look at experiments, data collection, data processing and evaluations. No tools are allowed. Exam duration: 60 minutes

Repeat Examination:
Next semester

(Recommended) Prerequisites:
As scientific working is essential for all disciplines the module may be attended by students of all kinds of studies.

Content:
The module of scientific working shall impart knowledge for preparing academic theses satisfying a scientific demand. The students discover different methods for scientific working as well as practical working methods and formal guidelines. The course shall illustrate how to prepare the state of knowledge of research as well as topic formulation at the beginning of a scientific work. An important focus of the module is research of literature. Students shall be taught how to handle libraries and quotable sources and shall be explained different possibilities of citation. Form and writing style as well as structuredness and goal orientation (thread) as essential elements of a scientific work shall be part of teaching in the module. Besides independence of participants as well as skills in working collaboratively and taking a very critical look at own results and approaches shall be developed.

Intended Learning Outcomes:
After successfully completing the module the students shall be qualified in preparing a scientific work by well-founded methodological approach. Participants also master a scientifically suitable form and language. They know the laws of good scientific working, correct citation methods and where scientific misconduct results in. In addition the students are able to plan a scientific work and estimate time requirement in a realistic way. Subsequent to this lecture they are able to take a critical look at an experiment and perform data collection, processing, evaluation and discussion.

Teaching and Learning Methods:
Lecture illustrating case studies. In the exercise ... shall be given and the term paper be mentored.

Media:
Presentations, slide scripts

Reading List:
Eco, U.; Schick, W. (2010): Wie man eine wissenschaftliche Abschlußarbeit schreibt (How to Write a Scientific Thesis). Heidelberg: UTB
Heesen, B. (2009): Wissenschaftliches Arbeiten (Scientific working). Vorlagen und Techniken für das Bachelor-, Master- und Promotionsstudium (Templates and Techniques for Bachelor, Master and Doctoral Studies). Berlin: Spinger
Rückriem, G. M.; Stary, J.; Franck, N. (2009): Die Technik wissenschaftlichen Arbeitens (Technique of Scientific Working). Eine praktische Anleitung (A Practical Instruction). Stuttgart: UTB
Davies, M. B. (2007): Doing a successful research project. Using qualitative or quantitative methods. Basingstoke: Palgrave

Responsible for Module:
Cordt Zollfrank (cordt.zollfrank@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Wissenschaftliches Arbeiten (Vorlesung) (Vorlesung, 3 SWS)
Van Opdenbosch D [L], Van Opdenbosch D

Wissenschaftliches Arbeiten (Übung) (Übung, 1 SWS)
Van Opdenbosch D [L], Van Opdenbosch D
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1642: Project Management | Projektmanagement

Version of module description: Gültig ab winterterm 2013/14

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Achievement of desired learning objectives shall be verified in a written final exam. In addition there is teamwork where the contents learned shall be applied through planning and performing of projects. A 20 minutes' presentation shall be assessed according to aspects of content and rhetoric and be integrated into assessment by 50%. Exam duration: In writing (60 minutes), orally (20 minutes)

Repeat Examination:
Next semester

(Recommended) Prerequisites:
WZ 1605 Betriebliche Ökonomie (Operational Economy), WZ 1622 Rechnungswesen und Controlling (Accounting and Controlling)

Content:
The lecture shall impart basics in project management. This includes: What are projects? What is project management? It deals with the approach of the project idea to result in performance and control including the five stages of a project: Analysis, definition, project order - planning, project structure plan, schedule - project realisation, project control - documentation and reporting. Furthermore methods and tools for performing a project shall be specified why projects fail, project management and team leadership.

Intended Learning Outcomes:
After attending the module the student will know basis of project management and project teamwork. They are able to process required and basic steps and necessary prerequisites for planning, performance or monitoring of projects. They reflect past own experiences and cope with possible problems of project work. They are able to develop a project design.

Teaching and Learning Methods:
'Teamwork with case studies, presentations

Media:
Presentations, slide scripts

Reading List:
SchulzWimmer, heinz: Projekte Managen (Managing Projects). Werkzeuge für effizientes Organisieren, Durchführen und Nachhalten von Projekten (Tools for Efficient Organisation, Performance and Follow-Up of Projects). Freiburg i. Breisgau 2002 - Litke, H.D.: Projektmanagement (Project Management): Methoden, Techniken und Verhaltensweiseisen (Methods, Techniques and Behaviours). München/Wien 1993

Responsible for Module:
Huber Röder (hubert.roeder@hswt.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Vorlesung
Projektmanagement
1 SWS

Übung
Projektmanagement
1 SWS
Huber Röder
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1660: Typesetting with LaTeX and Alternatives | Schriftsatz mit LaTeX und Alternativen [SchrisaLaAlt]

Good typesetting practices for scientific publications

Version of module description: Gültig ab summerterm 2022

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Exam achievement shall be done in the form of a written test (45 minutes). No tools are allowed.

Repeat Examination:

(Recommended) Prerequisites:
Basic IT skills

Content:
The module of typesetting with LaTeX and alternatives shall impart knowledge about the most important programmes for creation of written works by machine. After discussing general requirements for issuance of such a programme criteria for good typesetting shall be explained first. For that purpose it is already dealt with the individual prior knowledge and requirements of course participants. Different text processing programmes such as MS Word, Libre-/OpenOffice Writer, Abiword or Lotus Symphony may be treated e.g. Subsequently individual aspects of good typesetting will be implemented in a sample document. For that purpose comparison of used programmes constitutes an important didactic element. Comprehensively and within different programmes expedient and chronological approaches for creating a document will be discussed for that purpose. Also practicality in typical collaborative workflows will be discussed. Finally in-depth elements such as creating and integrating vector graphics and complex diagrams as well as calculation and integration of graphs will be treated. For that purpose search for solutions in the internet is an important element.

Intended Learning Outcomes:
After successfully completing the module the students are capable of selecting the typesetting programme suitable for their purpose. They are able to select the suitable support programmes and set up a strategy for document composition. Moreover they know limits and compatibilities of the respective programmes in the workflows and are able to proactively plan their documents to face all eventualities of collaborative and individual work.

Teaching and Learning Methods:
Speech, demonstration, practical performance in IT room

Media:
Writing on the board, demonstration, own workplace

Reading List:
https://de.wikibooks.org/wiki/LaTeX-Kompendium
Schlosser J. Wissenschaftliche Arbeiten schreiben mit LaTeX: Leitfaden für Einsteiger. mitp, Wachtendonk, (2014).

Responsible for Module:
Cordt Zollfrank cordt.zollfrank@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Schriftsatz mit LaTeX und Alternativen (Vorlesung mit integrierten Übungen, 4 SWS)
Van Opdenbosch D [L], Van Opdenbosch D
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1687: Introduction to Medicinal and Spice Plants | Einführung in die Heil- und Gewürzpflanzen [MSP]

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In an written exam the students shall demonstrate that they recognize the most important medical and spice plants from the European area. They shall demonstrate that they are able to explain cultivation methods as well as harvest and drying. They shall be able to represent the ingredients of medical and spice plants and medical effect by using examples. Type of exam: written, Exam Duration: 60 minutes

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Organic and Inorganic Chemistry, Botanics, Plant Production

Content:
Medicinal herbs history, presenting medical and spice plants, setting up of a herbarium, aspects of plant production for creating herb fields, their crop protection and harvest. Techniques for herb drying. Classes of agents such as terpenes, steroids, coumarins, alkaloids, vitamins, flavonoids. Connection between classes of agents and their medical effect. Basic mechanism of action of different classes of agents. Typical medicinal plants from European cultivated areas. Modern cultivation and use of medicinal plants in practice.

Intended Learning Outcomes:
After having participated in the module units the students are able to recognize medical and spice plants. They know basis of plant production for setting up a spice garden or fields. They know process technology basics for spice drying. They are able to designate the most important classes of agents. The students are able to call up connection between medical effect and chemical classes of agents by using typical examples. By having participated in the exercises in the spice

garden and laboratory work they are able to use simple analytical-chemical activities relating to plant analysis or assess their results.

Teaching and Learning Methods:
Lecture, speech by teaching staff by using PP media, books and other written material, setting up of a herbarium, study trip to a herb drying company. Exercise (e.g. Experimentation of students under supervision). Excursion on research fields (LfL) in Manching. Determine Herbs in a garden.

Media:
PP presentations and printed versions as documents. Laboratory equipment for experimentation, ready-made exercise analyses. Herbs for a determination and view on etheric oils.

Reading List:
Deutschmann, F., Hohmann, B., Sprecher, E., Stahl, E., Pharmazeutische Biologie (Pharmaceutical Biology), 3 volumes, G. Fischer Verlag, 1992
Wendelberger, E., Heilpflanzen (Medicinal Plants): Erkennen | Sammeln | Anwenden (Recognising | Collecting | Using) (paperback – BLV Buchverlag Januar 2013

Responsible for Module:
Corinna Urmann (alexander.hoeldrich@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Bachelor's Thesis | Bachelor's Thesis

Module Description

WZ1944: Bachelor's Thesis | Bachelor's Thesis

Version of module description: Gültig ab winterterm 2017/18

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 12	**Total Hours:** 360	**Self-study Hours:** 40	**Contact Hours:** 320

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module is completed with the preparation and positive evaluation of the Bachelor´s Thesis (depending on selection of topics 10 to 25 pages).

Repeat Examination:

(Recommended) Prerequisites:
120 credits, including all compulsory modules from the first four semesters, according to the module plan of the respective bachelor's program

Content:
consolidation of the knowledge of a specific biotechnological / bioeconomic topic which is arbitrary in consultation with the supervisor / consolidation of practical skills in the lab / presentation of a research-based topic in the field of biotechnology / Bioeconomy

Intended Learning Outcomes:
After completion of the module, the students are able to work self-reliant on simple scientific problems on the basis of scientific methods and analytical thinking. The can present their results in a conclusive way, are able to discuss and to draw conclusions.

Teaching and Learning Methods:
During the Bachelor´s Thesis, the students work on a scientific problem. At this juncture amongst others literature research as well as lab work and presentations are used. The actual teaching and learning methods depend on the respective problem and have to be discussed with the supervisor for each single case.

Media:
Specialist literature, software and so on

Reading List:
in consultation with the supervisor

Responsible for Module:
Prof. Anja Faße Prof. Volker Sieber

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

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