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

Module Catalog

B.Sc. Technology of Biogenic Resources

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 122

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

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

CS0065: Fundamentals of Thermodynamics | Grundlagen Thermodynamik

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 exam performance is effected by a written test. The students solve thermodynamical arithmetic problems and answer questions regarding the definitions and relations of thermodynamics. The students prove that they have understood the basic principles of thermodynamics by setting up and solving equations. Non-programmable calculators and a handed-out formulary are allowed aids. Exam duration: 90 minutes.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Mathematics

Content:
State variables, thermodynamic system, 1st and 2nd law, equations of state for ideal gases and fluid of constant density, process cycles, efficiencies, phase diagrams of pure substances

Intended Learning Outcomes:
After sucessful completion of the module the students know the 1st and 2nd law of thermodynamics; the are able to use thermal and caloric equations of state for ideal substance classes; they unterstand thermodynamic phenomena of phase change and related diagrams; they can apply the ideal gas law and the 1st and 2nd law to technical problems.

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:
Presentations, slide scripts, exercises

Reading List:
P. STEPHAN, K. SCHABER, K. STEPHAN, F. MAYINGER: Thermodynamik, Band 1 Einstoffsysteme
16. Auflage, Springer, Berlin (2006); H.D. BAEHR, S. KABELAC: Thermodynamik, 13. Auflage, Springer, Berlin (2006)

Responsible for Module:
Jakob Burger burger@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

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 | Pflichtmodule

Technical Mechanics 1 | Technische Mechanik 1

Module Description

MW1937: Engineering Mechanics 1 | Technische Mechanik 1

Version of module description: Gültig ab summerterm 2022

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

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

Description of Examination Method:
Die Lernergebnisse werden über eine Prüfungsleistung in Form einer 90-minütigen, schriftlichen Modulprüfung zum Ende des Semesters sowie über eine Übungsleistung (Studienleistung) in Form von semesterbegleitenden, elektronischen Tests (E-Tests) überprüft.
In der schriftlichen Modulprüfung wird anhand von Verständnis- und Rechenaufgaben in begrenzter Zeit und mit begrenzten Hilfsmitteln das Fach- und Methodenwissens überprüft. Die Studierenden sollen zeigen, inwieweit sie grundlegende Zusammenhänge und Berechnungsmethoden der Statik verstanden haben und selbstständig Problemstellungen der Statik analysieren und lösen können. Als Hilfsmittel sind in der eine Formelsammlung sowie ein nicht-programmierbarer Taschenrechner zugelassen.
Die Übungsleistung dient hingegen dazu, die Fertigkeiten (praktische Umsetzung, Anwendung und Nutzung des Fach- und Methodenwissens) ohne Zeitdruck und kontinuierlich inkl. Lernfortschritt zu überprüfen. Dabei wird also auf das didaktische Mittel zurückgegriffen, die Studierenden durch dauerhafte und aktive Auseinandersetzung mit einem Thema zu motivieren, um neues Wissen zu erwerben und die Fertigkeiten zu verbessern. Die Durchführung als verpflichtende Studienleistung hat sich dabei erfahrungsgemäß als erfolgreich erwiesen. Bei jedem E-Test handelt es sich um eine Übungsaufgabe zu einem Problem aus der Statik von geringem Umfang, die begleitend zur Vorlesung, Zentralübung und Vertiefungsübung digital auf der Online-Lernplattform Moodle bearbeitet wird. Pro E-Test werden den Studierenden jeweils zehn Versuche für die Eingabe des richtigen Ergebnisses gewährt. Während des Semesters werden im Abstand von etwa zwei Wochen insgesamt sechs E-Tests zum jeweils aktuellen Themengebiet gestellt. Die E-Tests ermöglichen den Studierenden eine Kontrolle ihres fortschreitenden Wissensstands in der Technischen Mechanik.

Die in der schriftlichen Modulprüfung erzielte Note entspricht der Note für das Modul. Im Sinne einer Studienleistung, die nicht in die Modulnote eingeht, müssen im Laufe des Semesters mindestens vier der sechs E-Tests erfolgreich bearbeitet werden.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Abiturwissen Mathematik (Differentiation, Integration etc.) und Physik (Kräfte, Hebelgesetz etc.)

Content:
Die Technische Mechanik stellt als Teilgebiet der Physik eine grundlegende Disziplin in den Ingenieurwissenschaften dar. Sie beschäftigt sich mit der Beschreibung und Vorherbestimmung der Bewegungen von Körpern und mit den damit einhergehenden Kräften. Ruhende Körper werden in der der Statik analysiert, die als Teilgebiet der Technischen Mechanik in diesem Modul behandelt wird. In erster Linie werden starre Körper, gegen Ende der Lehrveranstaltung aber auch elastische Körper untersucht. Es werden die folgenden Schwerpunkte gesetzt: Modellbildung in der Mechanik, Grundlagen der Statik, ebene und räumliche Tragwerke (Fachwerke, Balken, Rahmen und Bogenträger), Arbeitsprinzipien in der Statik, Reibung, Seilstatik, Dehnstäbe

Intended Learning Outcomes:
Nach erfolgreichem Abschluss des Moduls sind die Studierenden in der Lage, ruhende Tragwerke in der Natur und in der Technik zu identifizieren. Sie können mechanische Modelle aus der Realität extrahieren, klassifizieren und statisch bestimmte Systeme mithilfe der erlernten Methoden analysieren. Von besonderem Interesse sind hierbei die zwischen und innerhalb von starren Körpern auftretenden Kräfte. Zudem sind die Studierenden in der Lage, erste Zusammenhänge zwischen Kräften und Verformungen zu erkennen. Sie sind in der Lage, durch die vermittelte systematische und methodische Herangehensweise an Problemstellungen in der Technischen Mechanik, die Fähigkeit zu entwickeln, mechanische Fragestellungen in ingenieurwissenschaftlichen Problemen selbstständig zu formulieren und anschließend zu lösen.

Teaching and Learning Methods:
Die Vorlesung findet als Vortrag statt. Wichtige Inhalte der Vorlesung werden während des Vortrags auf einem Tablet-PC notiert und können von den Studierenden in das bereitgestellte Lückenskript übertragen werden. In der Zentralübung werden unter Anwendung der in der Vorlesung behandelten Inhalte beispielhaft Aufgaben vorgerechnet. Zudem werden jede Woche auf einem Übungsblatt zusätzliche Aufgaben veröffentlicht. Fragen zu diesen Aufgaben können im Rahmen der Vertiefungsübung in Kleingruppen gestellt werden. Für sonstige Fragen zum Lehrinhalt stehen täglich stattfindende Sprechstunden zur Verfügung. Während der Vorlesungszeit wird etwa alle zwei Wochen ein elektronischer Test (E-Test) zum aktuellen Themengebiet auf der Online-Lernplattform Moodle unter https://www.moodle.tum.de/ bereitgestellt. Die E-Tests werden online bearbeitet und anschließend umgehend automatisch bewertet.

Media:
Präsentation mit Tablet-PC, Lückenskript für Vorlesung, digitale Lehrmaterialien und elektronische Tests (E-Tests) auf Online-Lernplattform Moodle unter https://www.moodle.tum.de/

Reading List:
(1) Lückenskript für die Vorlesung
(2) D. Gross, W. Hauger, J. Schröder und W.A. Wall, Technische Mechanik 1: Statik, 12. Auflage, Springer Verlag, Berlin, 2013
(3) D. Gross, W. Hauger, J. Schröder, W.A. Wall und N. Rajapakse, Engineering Mechanics 1: Statics, 2. Auflage, Springer Verlag, Berlin, 2013
(4) W. Hauger, V. Mannl, W.A. Wall und E. Werner, Aufgaben zu Technische Mechanik 1-3: Statik, Elastostatik, Kinetik, 8. Auflage, Springer Verlag, Berlin, 2014

Responsible for Module:
Wall, Wolfgang A.; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Technische Mechanik I Übung (MW1937) (Übung, 2 SWS)
Goderbauer B, Wall W

Technische Mechanik I Vertiefungsübung (MW1937) (Übung, 2 SWS)
Goderbauer B, Wall W

Technische Mechanik I (MW1937) (Vorlesung, 3 SWS)
Wall W, Goderbauer B
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1980: Production of Biogenic Resources | Produktion biogener Ressourcen

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 a test. In this test it shall be proved that students are capable of describing important requirement for the required biogenic resources and are capable to devlop important rules for the production of the raw materials in a limited time. On the basis of different examples (e.g. algae productions) and scenarios the students shall discuss pros and cons and the possibilities for the transformation of the different biomass to products.
Type of exam: In writing
Exam duration: 90 min.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
None

Content:
The module aims at providing in-depth knowledge to the students in the prodution and cultivation of renewable raw materials. Beside the areal-bound production by agriculture and forest, production processes such as Algae bioreactors where integrated. Differences, advantages and disadvantages and possible perspectives are discussed.
Essential crop characteristics shall be discussed for the treated crops and if required differences shall be addressed by various product use (energy and/or industrial crops). As to crops important performance parameters (yields etc.) shall be debated and integration into a concrete cultivation system (farm) be discussed. For this purpose pros and cons shall be worked out and possible actions shall be discussed for optimizing cultivation. For selected topics current main points of research shall be presented and results discussed.

Intended Learning Outcomes:
After having participated in the module units the students know the most important biogenic ressources for renewable raw materials.
- They are capable of describing important requirement for the required biogenic resources and are capable to devlop important rules for the production of the raw materials
- For the desired raw materials, the required starting materials or biomass can be described (e.g. in the form of agricultural crops (example starch production: cereals, maize)). Based on the agricultural and wood procution of raw materials students can characterize the cropping system and cultivation methods
- They are able to describe possible effects on the environment for selected main crops (cereals, corn, oil crops)
- The students know selected research activities in the field of renewable raw materials and are able to analyse their results concerning their relevance and significance

Teaching and Learning Methods:
The module shall primarily be held as a lecture. For different courses it will be completed by individual and group projects. Demonstration of research activities and presentation of the cultivation by practitioners is partly performed by external guests (lecture, presentation). Further reading and questions for follow-up will be made available for different teaching units in moodle.

Media:
Lecture, presentations, (individual and group projects)

Reading List:
Lütke- 2006: Lehrbuch des Pflanzenbaus, Band 2: Kulturpflanzen, Verlag Th. Mann Gelsenkirchen.
Diepenbrock, Ellmauer, Leon, 2009 : Ackerbau, Pflanzenbau und Pflanzenzüchtung. Ulmer Verlag.
Pflanzenbau, Ein Lehrbuch - Biologische Grundlagen und Technik der Pflanzenproduktion, Gerhard Geisler, Paul Parey Verlag: Parasitäre Krankheiten und Schädlinge an landwirtschaftlichen Kulturpflanzen, Ulmer Verlag, G.-M. Hoffmann und H. Schmutterer
Diepenbrock 2014: Nachwachsende Rohstoffe, Ulmer UTB, Stuttgart
Kaltschmitt etal. 2009: Energie aus Biomasse, Springer, Heidelberg

Responsible for Module:
Siebrecht, Norman; Dr. agr.

Courses (Type of course, Weekly hours per semester), Instructor:
Produktion biogener Ressourcen (Vorlesung, 4 SWS)
Höldrich A [L], Höldrich A
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 / Angleichung Chemie (Vorlesung) (Vorlesung, 2 SWS)
Riepl H [L], Riepl H

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

Module Description

CS0087: Electrical engineering | Elektrotechnik

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:
Examination is done with written exam of 90 minutes duration. Participants show that they are able to perform calculations using fundamental principles of electrical engineering (including DC and AC circuits). Furthermore, the participants demonstrate they understanding of energy conversion principles within the scope of electrical engineering by answering questions related to case examples.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Modules Mathematics I and II

Content:
Introduction to electrical engineering and electrical power engineering, comprising
- electrical charge, electrical field
- current, voltage, resistance
- electrical circuits, Kirchhoff's circuit laws
- magnetif field, induction
- power and energy associated with electromagnetism
- alternating current, pointer diagrams,
- semiconductors
- transformers, voltage levels
- electrical machines
- dangers from electrical currents

Intended Learning Outcomes:
After attending this module's courses the participants know the principles of electrical engineering and ist fundamental physical laws. They can apply fundamental equations of electrical engineering to perform calculations pertaining to electrical engineering and power engineering. In addition, the participants know about the various pathways for energy conversion relevant within electrical engineering.

Teaching and Learning Methods:
Lecture (oral presentation including writing on the board/document camera, PP media, cloze lecture notes), exercise (deepening of course contents with tutors) with work in small groups.

Media:
beamer presentation, cloze lecture notes, demonstration experiments

Reading List:
Fischer, R.; Linse, H. (2012): Elektrotechnik für Maschinenbauer, 14. Auflage, ISBN: 978-3-8348-1374-9;
Klaus Heuck, Elektrische Energieversorgung, 2010, Vieweg Teubner;
Panos Konstantin, Praxisbuch Energiewirtschaft, 2009, Springer;

Responsible for Module:
Josef Kainz josef.kainz@hswt.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

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

WZ1607: Basics Silviculture | Grundlagen Waldbau [BiS]

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:** 90	**Contact Hours:** 60

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

Description of Examination Method:
In a test the students shall give answers to silvicultural issues in their own words and without tools. In doing so definitions of different site characteristics and consequences for silviculture shall be given in short answers. In longer answers different silvicultural concepts shall be illustrated. One or more trees of the twenty economically most important tree types shall be determined by means of clear photos and/or branches with leaves. Type of exam: In writing, Exam duartion: 60 minutes

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basics of biology: WZ 1603
Basics of plant production WZ 1604
Basic knowledge of plant build-up, nutrient cycles, soil structures.

Content:
The module aims at providing to students basic knowledge of cultivation, breeding, harvest of trees as well as botany and dendrology. Special techniques and instruments of silviculture shall be imparted: Techniques of reforestation,
young plantation care,
Thinning,
Pruning, Forestry systems as well as
strategies for timber production with hardwood and softwood tree types.
For this purpose parts of location study and teaching of forest soils with pedogenesis and soil chemistry shall be imparted.

Intended Learning Outcomes:
After attending the module the students understand the most important basic forms of forest treatment as well as its ecological special features and the structure and dynamic of forest resources. The students recognize different forest-related tree types and are able to distinguish their demands. After attending this module the students are additionally able to explain different forest soils and different silvicultural farming strategies by using the given information from the fields of forest ecology and location study. Silvicultural techniques shall be recognized and may be used accordingly. The most important forest soil types shall be recognized by means of cross-sections.

Teaching and Learning Methods:
The course of basics of silviculture consists of one lecture, preparing and giving a speech for which material research is necessary and first rhetoric skill are trained. A study trip into the forest and lectures held by qualified personnel from practice on site at different stations with common rounds of questions shall open a deeper insight into the topic. For that purpose also first determination exercises shall be performed at the object in the forest. A cut out soil profile serves to recognize theoretically acquired knowledge of soil horizons.

Media:
In the course the following media forms shall be used:
Script, powerpoint, films, for lectures also blackboard and flipchart, for determination exercises also branches and leaves to be determined. Study trip.

Reading List:
Burschel, P. & Huss, J. 1987. Grundriss des Waldbaus (Ground Plan of Silviculture). Ein Leitfaden für Studium und Praxis (A Guide for Study d Practice). Parey, Hamburg und Berlin. 352 S.
Elverfeldt, Freiherr von A. Rittershofer, F. 1999. Waldpflege und Waldbau (Forest Management and Silviculture). Für Studium und Praxis (For Study and Practice). 492 S.

Responsible for Module:
Alexander Höldrich (alexander.hoeldrich@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Vorlesung
Grundlagen Waldbau
3 SWS
Übung
Grundlagen Waldbau
1 SWS

Alexander Höldrich (alexander.hoeldrich@tum.de)
Cordt Zollfrank (cordt.zollfrank@tum.de)
For further information in this module, please click campus.tum.de or here.

Module Description

CS0130: Basic Biology | Grundlagen Biologie [GBio]

Version of module description: Gültig ab winterterm 2021/22

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**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:
Learning outcomes shall be verified in a written test in which the students are to call up and remember important basics of biology without tools. Besides the students shall demonstrate that they are capable of recognizing and solving a problem in a given time by answering questions of comprehension relating to treated basic biological and biotechnological processes. The answering of the questions requires own formulations. Thus correct memory of important technical terms shall be verified as well. Exam duration: 60 minutes

Repeat Examination:
Next semester

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

Content:
Signs of life, basics of cell biology, essential biomolecules, genetic information flow and basics of molecular genetics, important metabolic pathways (e.g. glycolysis, citrate cycle), transport processes, basics of biological systematics, use of microorganisms in industrial biotechnology, basic techniques of molecular biology

Intended Learning Outcomes:
After attending the module the students possess basic knowledge about structure and function of biomolecules. They know important components of procaryotic and eucaryotic cells and are able to differentiate between these forms of life. They know the basics of the genetic flow of information and the most important metabolic pathways and are able to assign bacteria, fungi and plants to higher- ranking systematic groups. Furthermore the students are able to convey technical terms and define processes and are able to use their knowledge to solve issues. They show a basic understanding for ecological challenges as a prerequisite for sustainable development.

Teaching and Learning Methods:
The teaching content is conveyed by means of lectures, based on ppt presentations and writing on the blackboard.

Media:
Presentation, writing on the board,

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

Responsible for Module:
Erich Glawischnig glawischnig@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Grundlagen Biologie (Vorlesung) / Angleichung Biologie (Vorlesung, 2 SWS)
Glawischnig E [L], Glawischnig E
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

CS0088: Measurement and Control | Mess- und Regelungstechnik

Version of module description: Gültig ab winterterm 2020/21

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 duration (in min.): 90. Proof of performance is provided in the form of a written examination. The students should prove that that essential concepts of measurement and control can be compiled, have been understood, can be presented in compressed form and procedures for evaluation can be applied. This implies in particular various aspects of error calculation, statistics, practical measurement technology, analysis of dynamic systems and controller design. Students should be able to create analytical solutions to problems from the mentioned subjects under time pressure and only with a simple calculator

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundations mathematics, electrical engineering

Content:
Theoretical basics of measurement technology, statistics, error propagation, practical effects, basics of electrical engineering for low-voltage measurement technology. Fundamentals of sensor technology and analog-to-digital conversion. Terms in control, modelling, laplace transformation, analysis of dynamical systems, feedback control and stability, controller design

Intended Learning Outcomes:
By completion of the module, the students are able to
- understand the problems of practical measurement with respect to accuracy,
- interpet measurement results,
- understand the basics of measurement in low voltage applications, the basics of sensoring, and the basics of analog-to-digital conversion,
- set up models of simple mechanical and electical systems in the time and frequency domain,

- analyse system properties like stabillity, transfer behavior, linearity,
- calculate system responsen with the help of the Laplace-Transformation,
- apply simple controller designs in the time and frequency domain and apply stability criteria,

Teaching and Learning Methods:
lectures with experiments and exercise

Media:
powerpoint/PDF-presentions, blackboard,
experiments

Reading List:
- Moeller, Fricke, Frohe, Vaske: Grundlagen der Elektrotechnik. B.G.Teubner, Stuttgart (2008).
- Bantel, M.: Grundlagen der Messtechnik Messunsicherheit von Messung und Messgerät. Fachbuchverlag Leipzig (2000).
- Schanz, G.W.: Sensoren. Hüthig Verlag, Heidelberg (2004)
- Föllinger, O.: Regelungstechnik. 10. Auflage, Hüthig-Verlag 2008. Ein Standard-Werk. Der Vorlesungsstoff wird bis auf wenige Ausnahmen gut abgedeckt.
- Lunze, J.: Regelungstechnik 1 Springer 1997. Lehrbuch in 2 Bänden, dessen 1. Band das den Stoff ebenfalls gut abdeckt. Viele Beispiele und Übungsaufgaben, auch mit MATLAB.
- Isermann, R.: Regelungstechnik I. Shaker Verlag 2002
- Horn, M. und Dourdoumas, N.: Regelungstechnik. Pearson Studium 2004

Responsible for Module:
Prof. Matthias Gaderer

Courses (Type of course, Weekly hours per semester), Instructor:
Mess- und Regelungstechnik (VO) (Vorlesung, 2 SWS)
Gaderer M [L], Putra L

Mess- und Regelungstechnik (UE) (Übung, 2 SWS)
Gaderer M [L], Putra L
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

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 (Vorlesung) (Vorlesung, 2 SWS)
Gaderer M [L], Huber B

Strömungsmechanik (Übung) (Übung, 2 SWS)
Gaderer M [L], Huber B
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 (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Zollfrank C

Biopolymere (Vorlesung) (Vorlesung, 2 SWS)
Zollfrank C [L], Zollfrank C
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

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

CS0214: Energy Technology | Energietechnik

Version of module description: Gültig ab summerterm 2021

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

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 demonstrate that they are able to solve computational tasks of electricity and heat generation relating to energy technology. It shall be proven that the students have understood the principles of thermal energy conversion. Type of exam: In writing, Exam duration: 180 minutes; auxiliary means: calculator

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Modules Physics (WZ1600), Mathematics 1 (CS0175), Fundamentals of Thermodynamics (CS0065)

Content:
In the module, the fundamentals of technical thermodynamics and thermal and decentralised energy technology are taught above all. The focus is on compressors, turbines, circuits for power processes, fuels, calorific value, the combustion of solid fuels, centralised and decentralised power plant technology as well as combined heat and power, refrigeration technology and solar thermal systems.

Intended Learning Outcomes:
After participating in the module, students are able to explain the basics of technical thermodynamics and thermal energy technology as well as the function and use of the different techniques. They can apply basic equations and perform them for energy balancing.

Teaching and Learning Methods:
The lecture is given in combination in handwritten form (digital projected) and/or with PowerPoint. In exercises, the energy conversion is demonstrated and discussed with examples. The lecturer will explain and discuss the exercise results in the overall context.

Media:
Script will be provided in part, blackboard transcript or digital written presentation, Power Point slides, exercises.

Reading List:
- Pischinger, R.; Klell, M.; Theodor, S.: Thermodynamik der Verbrennungskraftmaschine, 3. Auflage, Springer-Verlag, ISBN 978-3211-99279-0, 2009
- Stephan, P.; Schaber, K.; Stephan, K.; Mayinger, F.: Thermodynamik, Band 1: Einstoffsysteme, 17. Auflage, Springer, ISBN 978-3-540-70813, 2006
- Baehr, Hans Dieter; Kabelac, Stephan: Thermodynamik, 14. Auflage, Springer, ISBN 978-3-642-00555-8, 2009
- 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
- Atkins, Peter W.: Physikalische Chemie, VCH, ISBN 3-527-25913-9, 1990
- VDI Wärmeatlas, VDI-Gesellschaft Verfahrenstechnik und Chemie-Ingenieurwesen 9.Auflage, Springer-Verlag ISBN 3-540-41201-8 9.Auflage
-Schnitzer, H.: Grundlagen der Stoff- und Energiebilanzierung, 9. Auflage, Vieweg, ISBN 3-528-04794-1, 1991
- Kaltschmitt, M.; Hartmann, H.; Hofbauer, H.: Energie aus Biomasse, 2. Auflage, Springer, ISBN 978-3-540-85094-6, 2009
- Karl, J.: Dezentrale Energiesysteme, Oldenbourg, ISBN 3-486-27505-4, 2004

Responsible for Module:
Matthias Gaderer

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

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

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

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

CS0093: Energy and process engineering lab | Grundlagenpraktikum Energie- und Verfahrenstechnik

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:** 75	**Contact Hours:** 75

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

Description of Examination Method:
In the practical course, the exam is taken by positively elaborated written internship reports (for each experiment about 5 pages of report). Thereby the correct presentation of the theoretical basics, the reproduction of the experimental procedure and the correct data evaluation are essential. Thereby the students show that they understand basic processes and principles of energy and process engineering and that they can design and calculate corresponding transformations. The students prove that they can execute and evaluate metrological experiments in small groups (2-3 persons).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Chemical reaction engineering, Fluid separation processes, Energy Technology

Content:
Basic operations of energy and process engineering, especially from the chemical, thermal and mechanic range e.g. destillation or particle distribution analysis.

Intended Learning Outcomes:
After graduation of the practical course, the students know basic processes and principles of process engineering (e.g. heat transfer and separation techniques). 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. The content and the number of experiments are chosen from a of multiplicity of basic operations and rely on the available laboratory equipment.

Media:
Practical course script, laboratory equipment

Reading List:
Practical course script

Responsible for Module:
Jakob Burger burger@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Grundlagenpraktikum Energie- und Verfahrenstechnik (Praktikum, 5 SWS)
Burger J [L], Burger J
For further information in this module, please click campus.tum.de or here.

Module Description

CS0095: Cooperative Design Project | Kooperative Projektarbeit

Version of module description: Gültig ab winterterm 2020/21

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 8	**Total Hours:** 240	**Self-study Hours:** 210	**Contact Hours:** 30

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

Description of Examination Method:
The module will be completed with the production and grading of a written final report. In the report, the students shall describe problem, solution approach, individual assignments within the project team, calculations, and analyses in concise fashion. The personal contributions of the individual student shall be described. In regular meetings with the supervisor, the individual contributions are monitored.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamentals of Thermodynamics, Basics on renewables utilization

Content:
The task describes a technical problem in the field of the use of biogenic resources for which the team has to find a solution. Examples are e.g:
1. preparation of a concept and design of a biogas plant for an agricultural business
2. Feasibility Study on the conversion of high performance packaging in space application from fossil-based plastics to bio-based plastics

Intended Learning Outcomes:
"After successful participation in the module, the students will be able to
- understand and classify the cooperation in a team with heterogeneous knowledge base,
- apply the basics of process and energy engineering to practical problems
- discuss the interrelationships between different aspects of a project (time management, balancing, interaction, objectives),
- present self-developed balance sheets and calculation results in text form,
- carry out work in a hierarchical organisation"

Teaching and Learning Methods:
The module consists of a project work, which is carried out in a cooperative team between Bachelor and Master students. Depending on the given task, the team size is 2-6 persons. The Master students assume the role of project leaders and are responsible for formulating and achieving the project goals. The Bachelor students carry out research, analysis and calculations and are supported by the Master students if required. Progress, role identification, and individual involvement are monitored in regular meetings with the supervisor.

Media:
Will be adapted to task at the project start by the supervisor

Reading List:
Rowe, S. (2015). Project Management for Small Projects, 2nd Edition. Oakland: Berrett-Koehler Publishers.
Specific literature will be announced by the supervisor before the project starts.

Responsible for Module:
Jakob Burger burger@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
(Kooperative) Projektarbeit (Praktikum, 8 SWS)
Gaderer M [L], Herdzik S, Huber B, Meilinger S, Putra L, Schenker M, Veiltl P
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.

Material Fundamentals | Werkstoffkunde

Module Description

CS0040: Material Fundamentals | Werkstoffkunde [Wkd]

Version of module description: Gültig ab winterterm 2020/21

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 course will be evaluated in a 90 minute written exam.
In the examination, students shall demonstrate their knowledge of the fundamentals of materials from all classes of materials. They shall demonstrate their ability to sketch processing routes and aspects of applications.

Repeat Examination:

(Recommended) Prerequisites:
None

Content:
This module covers the fundamental material classes, their typical properties and applications. Further, the technologically most important materials, their production, properties and applications from each class will be discussed.

Intended Learning Outcomes:
After completion of the module, the participants are enabled to name typical properties of the basic material classes. They can name technologically important materials and routes for their preparation, as well as typical applications.

Teaching and Learning Methods:
The module shall be organised as a lecture, i.e. presentations are performed by PP media. Based on book reviews self-instruction will be encouraged. Illustrating examples and case studies will be used to clarify and deepen the course contents.

Media:
Blackboard, slides

Reading List:

Responsible for Module:
N.N.

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

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

Module Description

WZ5005: Material Science | Werkstoffkunde

Version of module description: Gültig ab summerterm 2023

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 120	**Contact Hours:** 30

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

Description of Examination Method:
Die Prüfungsleistung wird in Form einer benoteten Klausur erbracht (60 Minuten). Die Studierenden müssen in der Prüfung darlegen, dass Sie kristalline Gitterstrukturen anhand von vorgelegten Beispielen verstehen. Sie müssen die Eigenschaften verschiedener Werkstoffgruppen kennen sowie die Phasenverhalten verschiedener Werkstoffe anwenden. Sie müssen die Herstellung von Stahl an einem gewählten Beispiel im Phasendiagramm nachvollziehen und die Festigkeit des entstandenen Materials bewerten. Sie sollen nicht-metallische Werkstoffe unterscheiden und deren Vor- und Nachteile für Beispiele, sowohl im Lebensmittel- und Getränkebereich, als auch im Maschinen- und Apparatebau diskutieren. Sie sollen die Ursachen der Korrosion, die verschiedenen Korrosionsarten sowie Möglichkeiten des Korrosionsschutzes kennen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Grundkenntnisse in Technischer Mechanik, Chemie, Physik und physikalischer Chemie

Content:
"Im Modul Werkstoffkunde werden die grundlegenden Aspekte der Materialwissenschaften sowie Werkstofftechnik behandelt:
- Struktur kristalliner Festkörper: Gitterstruktur, Klassen, Defekte in Kristallsystemen
- Phasendiagramme und deren Einsatz in der Stahlproduktion: Herleitung, Übergänge, Erstarren, Kristallisation, Schmelzen, Beispiel Wasser, mischbare und unmischbare Systeme, Hebelgesetze, Eisen-Eisencarbid-System, Stahlerzeugung
- Mechanische und physikalische Eigenschaften von Stoffen
- Nichtmetallische Werkstoffe: Kunststoffmonomere und -polymere, Herstellung, Duro-/ Thermoplasten, Elastomere, Formgebung, Additive, mechanische Eigenschaften, Alterung

- Festigkeitslehre: statisch (Torsion, Spannung, Schub, Dehnung), Elastizität, Dauerfestigkeit, Härte
- Metallische Werkstoffe: Herkunft, Roheisengewinnung, Verfahren zur Stahlproduktion, Stahleigenschaften im Maschinen- und Anlagenbau, Härten, Vergüten, Legierungen, Korrosion"
- Nichtmetallische Werkstoffe Glas und Keramik, Herstellung, Werkstoffeigenschaften und Unterschiede
- Verbundwerkstoffe

Intended Learning Outcomes:
Nach dem Modul sind die Studierenden in der Lage, geeignete Werkstoffe für den Maschinen- und Anlagenbau auszuwählen. Sie kennen die chemischen Strukturen und den molekularen Aufbau und können anhand der kristallinen oder amorphen Struktur Festigkeiten und Belastbarkeiten einschätzen. Sie kennen die verschiedene Stahlsorten und deren Aufbau und können deren Herstellverfahren und die entstanden Eisenstruktur diskutieren. Sie können Festigkeitskennwerte beurteilen und kennen die gängigsten Verfahren der Werkstoffprüfung. Sie kennen alle für den Anlagenbau und die Lebensmittelindustrie wichtigen Kunststoffe und können deren Anwendung beurteilen. Sie verstehen verschiedene Ursachen von Korrosion und kennen die Schutzmechanismen diesen Prozess zu unterbinden.

Teaching and Learning Methods:
Das Modul besteht aus einer wöchentlich stattfindenden Vorlesung mit interaktiven Elementen.

Media:
Die Folien werden über moodle bereitgestellt. Ebenso gibt es Erklärvideos.

Reading List:
Technische Mechanik 2 - Festigkeitslehre von Russell C. Hibbeler, Pearson Studium

Materialwissenschaften und Werkstofftechnik von Callister und Rethwisch, Wiley-VCH

Werkstoffkunde für Ingenieure von Roos und Maile, Springer Verlag

Werkstoffkunde von Bargel und Schulze, Springer Verlag

Responsible for Module:
Schrettl, Stephen, Prof. Dr. stephen.schrettl@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

MW1984: Engineering Materials 1 | Werkstoffe des Maschinenbaus 1

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:
Die Modulprüfung erfolgt in Form einer 90-minütigen, schriftlichen Klausur. Diese kann aus Auswahlaufgaben (Multiple Choice), offenen Kurzfragen sowie vertiefenden Verständnis- und Rechenaufgaben bestehen.
Innerhalb der begrenzten Zeit und mit den vorgegebenen Hilfsmitteln sollen die Studierenden nachweisen, dass sie den grundlegenden Aufbau und die Eigenschaften von Werkstoffen unter Verwendung von Fachvokabular beschreiben und die zugrundeliegenden Zusammenhänge erläutern können. Dieses Grundlagenwissen soll auf praktische Fragestellungen der Werkstoffkunde übertragen werden, um diese analysieren und mögliche Lösungen entwickeln zu können.
Als Hilfsmittel sind Schreibutensilien, Lineal/Geodreieck sowie ein nichtprogrammierbarer Taschenrechner zugelassen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Kenntnisse in Höherer Mathematik 1 und 2, Physik und Chemie

Content:
Im Modul werden die grundlegenden Gesetzmäßigkeiten und Mechanismen der Werkstoffkunde vermittelt. Es wird gezeigt, wie Aufbau und Eigenschaften von Werkstoffen zusammenhängen. Dies umfasst im Einzelnen die folgenden Themen:
- Rolle der Werkstoffe im Maschinenbau
- Aufbau der Werkstoffe
- Struktur kristalliner Werkstoffe
- Erstarrung
- Fehlstellen in Festkörpern

- Diffusion / Kinetik
- Versetzungen und Verfestigungsmechanismen
- mechanische Eigenschaften metallischer Werkstoffe
- Werkstoffversagen
- Korrosion und Degradation von Werkstoffen
- Phasendiagramme
- Bildung von Mikrostrukturen und Änderung mechanischer Eigenschaften

Intended Learning Outcomes:
Die Studierenden sind nach erfolgreicher Teilnahme an diesem Modul in der Lage:
- Aufbau und Eigenschaften von Werkstoffen mittels Fachvokabular zu beschreiben;
- Zusammenhänge zwischen Struktur und Eigenschaften von Werkstoffen zu erklären;
- die physikalischen und chemischen Eigenschaften von technischen Werkstoffen zu vergleichen und zu beurteilen;
- das Grundlagenwissen auf praktische Anwendungen im Maschinenbau zu übertragen, um einfache Problemstellungen zu analysieren und zu lösen.

Teaching and Learning Methods:
Das Modul besteht aus drei Teilen (Vorlesung, Zentralübung und Tutorium), die sich gegenseitig ergänzen.
In der Vorlesung wird das grundlegende Wissen vor allem mittels Präsentationsvideos vermittelt. Einzelne Themen werden in Erklärvideos vertiefend betrachtet. Diese Inhalte werden online bereitgestellt und können somit jederzeit im Selbststudium erarbeitet werden. Ergänzt wird das Angebot durch elektronische Tests, mit denen die Studierenden ihr Wissen überprüfen können. Darüber hinaus werden in Live-Veranstaltungen die wesentlichen Inhalte zusammengefasst und tagesaktuelle Beispiele der angewandten Werkstoffkunde interaktiv besprochen.
Die Zentralübung widmet sich der Anwendung des erlangten Wissens anhand konkreter Problemstellungen der angewandten Werkstoffkunde. Die Lösungen werden zusammen mit den Studierenden erarbeitet, sodass ihnen der Einstieg in die selbstständige Bewältigung ermöglicht wird.
Diese erfolgt sodann anhand konkreter Aufgaben, die den Studierenden elektronisch bereitgestellt werden. Sollten diese Hilfestellung bei der selbstständigen Lösung der Aufgaben benötigen, stehen wissenschaftliche und studentische Mitarbeitende des Lehrstuhls in Tutorien und Sprechstunden unterstützend zur Seite.

Media:
Folienpräsentation
Präsentationsvideos
Erklärvideos
Elektronische Tests
(Elektronische) Tafelbilder
Aufgabenblätter (digital)

Reading List:
Callister, Rethwisch: Materialwissenschaften und Werkstofftechnik: Eine Einführung, 1. Auflage, Wiley-VCH, Weinheim, 2013

Responsible for Module:
Mayr, Peter; Prof. Dr. techn. Dipl.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Werkstoffkunde 1 Tutorium (Übung, 2 SWS)
Dai Z (Rotzsche S, Hempel N, Mayr P), Hegele P (Reichert L, Röhrer D, Apfelbacher L, Torgersen J)

Werkstoffkunde 1 (Vorlesung, 3 SWS)
Mayr P (Rotzsche S, Dai Z), Torgersen J (Reichert L, Röhrer D, Hegele P)

Werkstoffkunde 1 Übung (Übung, 1 SWS)
Reichert L (Röhrer D, Hegele P, Torgersen J), Rotzsche S (Dai Z, Mayr P)
For further information in this module, please click campus.tum.de or here.

Technical Electives | Fachspezifische Wahlmodule

Module Description

WZ1162: Practical Course Renewable Raw Materials | Praktikum Nachwachsende Rohstoffe

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** German	**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:
"Eine Studienleistung wird durch die korrekte Durchführung aller Laborexperimente mit korrekter Protokollierung erbracht. Damit weisen die Studierenden nach, dass sie die vermittelten experimentellen und analytischen Arbeitstechniken anwenden und Laborexperimente ordnungsgemäß dokumentieren können. Optional können vor Versuchsbeginn schriftliche oder mündliche Antestate zu den Versuchsbeschreibungen im Praktikumsskript als weitere Studienleistung eingefordert werden, um die angemessene Praktikumsvorbereitung der Studierenden zu zeigen.
Nach Ende des Praktikums findet eine mündliche Prüfung statt, in der die Studierenden nachweisen sollen, dass sie die den Versuchen zugrundeliegenden Prozesse und Reaktionen sowie die Hintergründe der eingesetzten experimentellen Arbeitsschritte verstanden haben. "

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Erforderlich: Vorlesung "Einführung in die stoffliche Nutzung" sowie gegebenfalls Angleichungsmodule "Grundlagen Chemie" und "Grundlagen Biologie" oder vergleichbares Vorwissen.

Content:
In Laborexperimenten werden zentrale Schritte ausgewählter chemischer und bio(techno)logischer Prozesse zur Herstellung von Chemikalien, Werkstoffen und Energieträgern aus nachwachsenden Rohstoffen nachvollzogen. Weiterhin werden allgemein notwendige Grundlagen für das Arbeiten in chemischen und mikrobiologischen Labors sowie spezielle analytische

Methoden vermittelt, um Substrate und Produkte zu charakterisieren (u.a. Enzymassays, Dünnschichtchromatographie, Kapillarviskosimetrie, HPLC, Infrarotspektroskopie, spezielle Methoden zur Polymercharakterisierung).

Intended Learning Outcomes:
Nach Praktikumsteilnahme besitzen die Studierenden ein vertieftes Verständnis für die ausgewählten Beispielprozesse und die zugrundeliegenden Reaktionen. Sie sind mit dem Arbeiten in chemischen und mikrobiologischen Labors in den Grundzügen vertraut und in der Lage, die vermittelten speziellen experimentellen und analytischen Methoden mindestens in den Grundzügen anzuwenden und Laborexperimente korrekt zu protokollieren.

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

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

Reading List:
Praktikumsskript

Responsible for Module:
Doris Schieder (doris.schieder@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Praktikum
Praktikum Nachwachsende Rohstoffe
6 SWS

Doris Schieder (doris.schieder@tum.de)

Cordt Zollfrank (cordt.zollfrank@tum.de)
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 (Exercise) (Übung, 2 SWS)
Thielen C [L], Thielen C

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

Module Description

CS0086: Wood-Based Resources | Holz als Rohstoff

Version of module description: Gültig ab winterterm 2023/24

Module Level:	Language:	Duration:	Frequency:
Bachelor	German/English	one semester	
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	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 test. Product pathways of forestry and forest industry shall be reflected here. Classification of economic and ecological aspects of forestry and forest industry from cultivation to material and energetic use shall be explained by using examples of particular cases. Recognition of wood and wood materials shall be shown. The relation of knowledge of forestry and forest industry with regard to knowledge of different woods and wood utilisation will be evaluated at a ratio of 1 to 1. The answers require own formulations from the respective technical jargon of forestry and forest industry.
Type of exam: In writing. Exam duration: 90 minutes.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:

Content:
The module aims at providing in-depth knowledge to the students in the field of forestry and forest industry from harvest to the use of wood. Special emphasis is given to the interfaces concerning wood use (sawing, wood materials and paper industry) and energy wood production. In a further aspect differences of woods shall be addressed from a microscopic point of view through to their field of application in the manufacturing industry. Therefore, students learn to classify woods microscopically and macroscopically.

Intended Learning Outcomes:
After attending the module the student shall be able to characterise the product pathways in forestry from crop establishment through to material and energetic use of wood. He distinguishes different forms of economy and is able to classify them according to economic, social and

ecological aspects. He recognises differences of woods, knows various new products produced from wood and understands
their production paths and their markets.

Teaching and Learning Methods:
The course attendance of forestry and wood consists of a lecture and one exercise. For this purpose powerpoint presentations amd practical training material shall be used. A study trip to wood processing plants including lectures from qualified personnel providing information from experience on site with common rounds of questions provides in-depth knowledge of the production paths. A socalled wood block determination, i. e. the determination of wood by means of different genuine wood samples, will be performed by a magnifying glass 10x.

Media:
The following forms of media apply: Script, powerpoint, films, for determination exercises also branches and leaves of shrubs to be determined. Study trip to companies with guided tour of processing and treatment of wood. Determination of wood with a magnifying glass 10x.

Reading List:
Jörg van der Heide, 2011: Der Forstwirt. (The Forester) Publisher: Ulmer (Eugen); Auflage: 5th edition. (September
26, 2011)
Language: German
ISBN-10: 3800155702
ISBN-13: 978-3800155705; D. Fengel, G. Wegener: Wood Verlag Kessel, www.forstbuch.de

Responsible for Module:
Prof. Cordt Zollfrank

Courses (Type of course, Weekly hours per semester), Instructor:
Wood-based Resources (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Röder H, Zollfrank C

Wood-based Resources (Exercise) (Übung, 2 SWS)
Zollfrank C [L], Röder H, Zollfrank C
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1654: Forest Management and Inventory | Forstmanagement und Waldinventur

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:
Exam achievement shall be done in the form of a written report. The students calculate the key performance indicators for forestal decisions and illustrate decision-making procedures and alternatives based on case studies. They show in the report that they are able to outline and explain forest management business processes. They demonstrate that they are able to answer problems on forest management and inventory in their own words. Exam achievement shall be completed by a presentation of the students for a specific and clearly defined topic. The report shall be weighted at a ratio of 30/70. Type of exam and exam duration: orally (20 minutes) or writing (60 minutes)

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Forestry and Wood WZ 1614, Knowledge about Forestal Processes, Crop Establishment and Timber Harvest, Forest Growth (Basics of Silviculture WZ 1607).

Content:
The module aims at imparting to students in-depth knowledge of forest management. For that purpose it is necessary to explain forest logistics. As well management requirement from forestry such as: Timber trade, wood evaluation and business organisation as a tool for reaching the objective, selection of tree types and risk management in view of rotation period, management objective and climate change, optimisation of biological production using the example of dominant tree species in Bavaria as well as sale of wood as a central process towards products, services and corresponding sales markets. The module also aims at developing understanding of the most important principles, sustainable management of forests and forestry.

Besides knowledge for practical performance of inventories and use of equipment including commonly used measuring instruments (cruising rod, altimeter, Vertex, Suunto) shall be imparted. Finally inventories are part of the lecture including complete enumeration as well as characterisation of forest resources.

Intended Learning Outcomes:
After attending the module the student will be able to use contents of forest management. He will be able to understand management processes in a forest company and implement principles to determine wood sorting and marketing in view of rotation period and management objective for a forest company.
It is possible for him to take selection decisions in a logical and transparent way by including economic and ecological criteria and thus understand central management processes in a forest company. The conflict of forest and game shall be understood concerning its impacts relevant for forest management. The students understand the use of measuring instruments for forest management and harvest planning. They are able to compare assessment of wood production of forest resources for different variants of timber harvest and implement it in practice.

Teaching and Learning Methods:
Project work using case studies in cooperation with a regional forest enterprise and AELF, practice by teamwork in the forest, presentation

Media:
Expert lecture, powerpoint, exercise sheets, measuring instruments

Reading List:
T. Knoke, Forstbetriebsplanung (Forest Operational Planning), 2012, 408 pages, 125 black-and white illustrations, Dimensions: 17,7 x 23,7 cm, Paperback (TB), German
Hrsg. v. Thomas Knoke ULMER EUGEN ISBN-10: 3800176114
ISBN-13: 9783800176113
H. Kramer, A. Akca, 1995, Leitfaden zur Waldmesslehre (Guide for Forest Mensuration) published by: Sauerländer, J D; edition: 3rd expanded and improved ed.
Burschel, P. & Huss, J. 1987. Grundriss des Waldbaus (Ground Plan of Silviculture). Ein Leitfaden für Studium und Praxis (A Guide for Study d Practice). Parey, Hamburg und Berlin. 352 S.
Elverfeldt, Freiherr von A.
Rittershofer, F. 1999. Waldpflege und Waldbau (Forest Management and Silviculture). Für Studium und Praxis (For Study and Practice). Gisela Rittershofer Verlag, Freising. 492 p.

Responsible for Module:
Hubert Röder

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

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

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

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

CS0073: Circular Economy | Circular Economy [CEC]

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:
Examination for course sizes of more than approx. 70 students:
Written exam (90 minutes): Students have to analyze, assess and discuss (simplified) circular economy concepts and legislative frameworks on a local, regional, national and global level, determine starting points for an optimization of these concepts and apply them to real-life use cases. Thereby, they have to take different points of view (environmental, product, (material flow) system, macroeconomic, business). In doing so, the students have to prove their ability to use the right vocabulary, and their knowledge on the motivation, and methods of circular economy.

Examination for course sizes of up to approx. 70 students:
The students demonstrate the above-mentioned capabilities through group work. In groups of 3-5 students they receive case-based problems of the CE. They have to solve these using the competencies obtained in the course. The results have to be presented and discussed (ca. 20') and 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:

Content:
The module covers the following topics:
• Introduction
• Circular Economy as a concept to approach sustainability needs
• History and policies related to the development of a circular economy
• Motivation for CE
• Design for Sustainability and Circularity
• Business model innovation for CE
• Closed-loop economic systems
• Sustainability Assessment of CE solutions
• Enablers and barriers, potentials and limits of CE
• Rebound effects
• Special topics and case studies

Intended Learning Outcomes:
Students explain the importance of the circular economy within the context of resource shortages, climate change and further sustainability challenges. They discuss and understand the central concepts of a circular economy against their historical background covering both, traditional waste management and recycling approaches as well as more recent holistic concepts. They asses and discuss CE from an environmental, product, material, and economic perspective. Based on these competences, they can develop action approaches to transfer these concepts from theory into practice. They link independently urgent environmental problems of our time with the concept of the circular economy and design solution approaches based on their results. Regarding value creation in a circular economy, the students identify business opportunities, develop and discuss new innovative business models. They apply these concepts to specific use cases, and assess their implications from different perspectives, considering potentials and limits, enablers and barriers.

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.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies / reading of scientific publications with presentation
- Individual assignments and presentation to consolidate/repeat the learned contents
- Dismantling and recycling exercises in the CE-lab
- Plenary discussions to reflect the lecture contents

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

Reading List:
Recommended reading:
• Ayres, Robert U. (2002): A handbook of industrial ecology
• Charter, Martin (2019): Designing for the circular economy, Routeledge
• De Angelis, Roberta (2018): Business Models in the Circular Economy: Concepts, Examples and Theory, Palgrave Macmillan
• Franco-García, María-Laura ; Carpio-Aguilar, Jorge Carlos ; Bressers, Hans: Towards Zero Waste: Circular Eocnomy Boost, Waste to Resources, Springer
• Larsson, Mats (2018): Circular Business Models: Developing a Sustainable Future
• Schaub, Georg; Turek, Thomas (2016): Energy Flows, Material Cycles and Global Development: a Process Engineering Approach to the Earth System, Springer
van Erwijk, S.; Stegemann, J. (2023): An Introduction to Waste Management and Circular Economy, UCL Press
• Webster, Ken (2017): The Circular Economy - A Wealth of Flows, Ellen MacArthur Foundation Publishing
• Wiesmeth, H. (2021): Implementing the Circular Economy for Sustainable Development, Elsevier
Further literature will be given in the course.

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

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

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

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

CS0190: 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 an oral question to ensure that the students are sufficiently familiar or familiarized with the safety-related facts of the practicum script/ topic and the asscoiated equipment. The service is provided in the form of written logs of the laboratory tests carried out (about two experiments and at least ten pages protocol per test). In these, the students should prove that they are able to understand the theoretical basics of the experiments, to document the execution of the experiments and to evaluate their results. They should also show that they can discuss deviations from the expected results and possible causes. Assessment of the internship as passed/failed. The internship is only passed if the protocol listed above meets the criteria of completeness, correctness, and comprehensibility/clarity to more than 50%, whereby feedback is given on a first draft.

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:
Horst Chmiel, Bioprozesstechnik,
Spektrum Akademischer Verlag Heidelberg 2011

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

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

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

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

CS0213: Environmental Resources in a Changing World | Environmental Resources in a Changing World

Resource availability, dependency and sustainable usage

Version of module description: Gültig ab winterterm 2024/25

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:
Students demonstrate their knowledge and understanding of the relevance of environmental resources, their limited availability, and approaches for a sustainable usage of resources in form of a written examination (90 minutes). Students deliver definitions, describe and outline relevant processes for selected environmental resources regarding their formation, utilization, supply, and sustainable use.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Knowledge and/or interest in Geology and Physics are valuable.

Content:
The course focuses on the different areas of life in which environmental resources play a critical role, such as drinking and irrigation water supply, energy provision, strategic mineral use, or sand as a building material. Thereby, an introduction to relevant expert knowledge such as formation, deposition, and utilization of relevant resources will be made. After understanding the formation of resources, their availability under current and future use in a changing environment can be assessed with special consideration of current and future demand on the resource production/ provision.

Intended Learning Outcomes:
After successful completion of the module, students understand the ecological and economic value of different environmental resources, the dependency on these resources, and the pressure

upon these resources through a changing world, such as climate and societal changes. Students comprehend the assessment of consequences of unsustainable resource use.

Students prepare short, practice-oriented tasks individually or in a project team (group work). Thereby, they acquire the ability to view and assess information within a limited period of time and solve practice-oriented questions. The edited information and results are shared with the other participants accordingly with a focus on the successful summary, presentation, and discussion of results.

Teaching and Learning Methods:
The content is taught in lectures and presentations. In addition, case studies and exercises will be discussed. Students should be encouraged to individual literature study and discussions on the theme.

Media:
Lecture, Power Point presentation, blackboard, case examples, topics prepared by participants, and round-table discussions.

Reading List:
H. Hettiarachchi & R. Ardakanian (eds.), 2016: Environmental Resource Management and the Nexus Approach. Managing Water, Soil, and Waste in the Context of Global Change. Springer, Cham.

Dassargues, A. (2018): Hydrogeology: Groundwater Science and Engineering, CRC Press, 1st edition.

Grotzinger, T. & Jordan, T. (2014): Understanding Earth. W.H. Freeman & Company, 7th edition

Responsible for Module:
Vienken, Thomas; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Environmental Resources in a Changing World (Vorlesung mit integrierten Übungen, 4 SWS)
Vienken T [L], Vienken T
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.

General Electives | Allgemeine Wahlmodule

Module Description

CLA11317: Interdisciplinary Lecture Series Environment: Politics and Society | Ringvorlesung Umwelt: Politik und Gesellschaft

Version of module description: Gültig ab summerterm 2015

Module Level: Bachelor/Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 1	**Total Hours:** 30	**Self-study Hours:** 15	**Contact Hours:** 15

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

Description of Examination Method:
A successful accomplishment of 9 academic performances is mandatory for the examination! The examination consists of a short PowerPoint presentation at the end of the semester. The presentation can be created alone or in groups of two. Everyone has to speak one minute. The examination is ungraded.

Repeat Examination:

(Recommended) Prerequisites:

Content:
The lecture series Umwelt (environment) is an interdisciplinary, public lecture organised by the Environmental Department of the Studentische Vertretung (Student Representatives) of the TU Munich. Experts speak e.g. on technical environmental protection, health, consumer and climate protection. In the summer semester, it offers students the opportunity to learn about the political and social dimensions of current ecological topics and research results at a scientific level.

The lecture series Umwelt (environment) is offered in the winter semester in the module CLA11200 Ringvorlesung Umwelt: Ökologie und Technik (Lecture series on the environment: ecology and technology). It is only possible to gain given credits twice for the lecture series within each study program.

Intended Learning Outcomes:
Students are able to follow expert presentations on political and social dimensions of environmental problems and identify core theses and central facts.

Teaching and Learning Methods:
Lectures, presentations, discussions

Media:

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Out of Sight, Out of Mind? A Journey into the World's Hidden Realities (Ringvorlesung) (Vorlesung mit integrierten Übungen, 1,5 SWS)
Nogueira de Carvalho M, Pahl A, Slanitz A
For further information in this module, please click campus.tum.de or here.

Module Description

CLA21411: Stress Competence | Stresskompetenz [EDS-M4]

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 2	**Total Hours:** 60	**Self-study Hours:** 30	**Contact Hours:** 30

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

Description of Examination Method:
Die Prüfungsleistung besteht aus einem Bericht in Form einer schriftlichen Selbstreflexion (3-4 Seiten), in welchem zu den Themen des Kurses Stellung genommen und die diesbezügliche persönliche Entwicklung über vier Wochen nach dem Kurs nachzeichnet wird. Insbesondere werden Faktoren der Stressentstehung, eigene Denkweisen und Einstellungen sowie selbst erprobte Lösungsmöglichkeiten reflektiert. Zum Erreichen der Lernergebnisse ist es notwendig, zwischen den einzelnen Kurstagen Hausaufgaben zu erarbeiten (z.B. Kleine Übungen für den Alltag, Selbstreflexionsübungen, Lesen von Aufsätzen).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Die Teilnehmenden bringen ein persönliches Anliegen zur Verbesserung Ihres Umgangs mit Stress und Leistungsdruck mit.

Content:
Was ist Stress und wie kann ich mit Belastungen umgehen, um meine Energiewaage im Gleichgewicht zu halten?
Was sind meine persönlichen stressauslösenden Gedanken und wie kann ich sie positiv beeinflussen?
Wie zeigt sich der Stress in meinem Körper und wie kann ich bewusst in die Entspannung finden?

Höher, schneller, weiter… So fühlt es sich für viele Studierende an, wenn sie in möglichst kurzer Zeit möglichst gute Leistungen erbringen sollen. Oft gelingt es sehr gut, allen Anforderungen im Studium gerecht zu werden, doch manchmal nimmt der Druck überhand und Stress oder Gefühle der Überlastung stellen sich ein.

Basierend auf neuesten medizinischen sowie psychologischen Erkenntnissen erfahren Sie in dieser 3-tägigen Seminarreihe, wie Sie in solchen Situationen körperlich und mental fit bleiben und erlernen vielfältige Methoden, die Sie in Ihrem (Studien-) Alltag sofort anwenden können.

Intended Learning Outcomes:
Ziel des Moduls ist es, die Arbeits- und Lernfähigkeit der Teilnehmenden wieder herzustellen bzw. Möglichkeiten kennen, die eigene Leistungsfähigkeit dauerhaft zu erhalten.
Nach der Teilnahme sind die Studierenden in der Lage
- biologische, psychische sowie soziale Prozesse der Stressentstehung zu verstehen
- förderliche Denkweisen und Einstellungen zu entwickeln
- unterschiedliche Entspannungsmethoden erfolgreich anzuwenden
- und individuelle Lösungen für einen gesunden und gelasseneren Umgang mit Belastungen zu finden.

Teaching and Learning Methods:
Theoretischer Input, Selbstreflexion, Einzel- und Gruppenarbeit, Praktische Übungen

Media:

Reading List:

Responsible for Module:
Vierthaler, Barbara; Dipl.-Päd. (Univ.)

Courses (Type of course, Weekly hours per semester), Instructor:
TK-MentalStrategien - stressfreier durchs Studium (Workshop, 2 SWS)
Brucks A

Stark durchs Semester: Ziele erreichen und die eigene Gesundheit im Blick behalten (Workshop, 2 SWS)
Müller-Hotop R
For further information in this module, please click campus.tum.de or here.

Module Description

CLA31900: Lecture Series Environment - TUM | Vortragsreihe Umwelt - TUM

Version of module description: Gültig ab winterterm 2019/20

Module Level: Bachelor/Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 67	**Contact Hours:** 23

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

Description of Examination Method:
The examination consists of a poster created in a group of 2-3 people connecting topics from at least two lectures. In order to collect material for the poster, participants have to organize themselves in discussion groups with 5-6 people.
Each discussion group will split into two groupes for the poster. At the end of the semester the poster has to be presented. Every member of the poster group has to speak one minute,
The grade will consist of the poster and its presentation.
Mandatory requirements for the examination
For the 3-ECTS course a successful accomplishment of 16 academic performances is mandatory for the examination!

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
The systematic integration of education for sustainable development at the university is an extremely complex challenge that can only be addressed through a plural and multi-perspective approach. Within the framework of the UNESCO World Programme of Action "Bildung für Nachhaltige Entwicklung“ (BNE; =Education for Sustainable Development), the interdisciplinary lecture series Umwelt - TUM takes place at the TUM Campus Garching, which deals with changing topics in the field of environmental sustainability.

It is organized by the newly founded branch of the environmental department AStA TUM at the Garching campus to promote sustainability awareness at TUM and to offer interested students the opportunity to deal with the topic in more detail.

Intended Learning Outcomes:
After successful participation in this module, students are able to understand lectures at a high scientific level and reproduce central statements. Students are able to comprehend analyses of sustainable development and are familiar with formulating their own positions and justifying them in discussions. Furthermore, they know where they can explore the topic of sustainability in more detail on campus, whether in the form of course offerings, internships, projects or thesis.

Teaching and Learning Methods:
It consists of six lectures and an organizational meeting at the beginning. Each lecture includes two 40-minute presentations, a 15-minute break and a subsequent 45-minute discussion with the speakers, which is realized in cooperation with the Zentrum for Schlüsselkompetenzen (Center for Key Competencies) of the Faculty of Mechanical Engineering.
The lectures and presentation slides will be uploaded to the online learning platform Moodle.
As homework, students will prepare a short report of the lectures and the discussion session. In addition, introductory and further literature will be addressed to enhance more detailed discussions of the lectures.

Media:

Reading List:

Responsible for Module:
Dr. phil. Alfred Slanitz (WTG@MCTS)

Courses (Type of course, Weekly hours per semester), Instructor:
Out of Sight, Out of Mind? A Journey into the World's Hidden Realities (Ringvorlesung) (Vorlesung mit integrierten Übungen, 1,5 SWS)
Nogueira de Carvalho M, Pahl A, Slanitz A
For further information in this module, please click campus.tum.de or here.

Module Description

CS0248: Markets for Renewable Energies and Biobased Products | Märkte für erneuerbare Energien und biobasierte Produkte

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:
The exam performance is effected by a written test. Through comprehension questions it is reviewed whether the students have understood principles of market development in the covered markets. The students answer questions regarding the development and current situation on the markets of renewable energies and biogenic products as well as the most important factors that influence this market development. The students prove that they have understood the interest and behaviour of actors being active on these markets by answering corresponding questions.
Exam duration: 90 minutes.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic know-how to the functioning of markets

Content:

A) Introduction and overview

B) Markets for renewable energies
- Regenerative electricity
- Regenerative heat /cooling
- Sustainable mobility
- Sector coupling

C) Markets for biobased products
- Chemical markets

- Building & Living
- Biomaterials
- Other markets (e.g. paper, cardboard, carton, natural cosmetics)

Intended Learning Outcomes:
After attending the module, students will be able to show the developments of markets for energy and biobased products and discuss market development. Students are familiar with the relevance, size, and important influencing factors on the renewable energy markets as well as markets for material use of biogenic resources. They are able to compare these markets, to capture important determinants of market development, and to identify the use of fossile and regenerative energies as well as the use of biomass for material applications in a macroeconomic and societal context thus developing strategies for future use.

Teaching and Learning Methods:
The lecture will be done using Powerpoint with specifically worked out presentation scripts. In addition, published studies and statistical data related to the development and situation on the targeted markets will be integrated into the lectures. Furthermore, current topics are discussed with students.

Media:
Slide presentation, Lecture recordings; Interactions using Moodle; selected journal articles; current topic-related news, videos

Reading List:
Quaschning, Volker (2020): Erneuerbare Energien und Klimaschutz: Hintergründe – Techniken und Planung – Ökonomie und Ökologie – Energiewende. 5. Auflage. Hanser Verlag: München.

FNR (2014): Marktanalyse Nachwachsender Rohstoffe. Schriftenreihe Nachwachsender Rohstoffe 34. Gülzow.

Responsible for Module:
Thomas Decker

Courses (Type of course, Weekly hours per semester), Instructor:
Märkte für erneuerbare Energien und biobasierte Produkte (Vorlesung, 4 SWS)
Menrad K [L], Decker T, Emberger-Klein A, Menrad K
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:
Experimental Lab - Projektarbeit (Projekt, 2 SWS)
Stierstorfer V [L], Stierstorfer V

Spannungsfeld Architektur, Wissenschaft & Design; begleitende Übungen (Vorlesung mit integrierten Übungen, 1 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

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

CS0094: Bachelor's Thesis | Bachelor's Thesis

Version of module description: Gültig ab winterterm 2020/21

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 12	**Total Hours:** 360	**Self-study Hours:** 180	**Contact Hours:** 180

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 100 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 topic in the area of technology of biogenic resources which is arbitrary in consultation with the supervisor / consolidation of practical skills in the lab / presentation of a research-based topic

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:
Jakob Burger burger@tum.de

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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