Module Catalog

M.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 154

Compulsory Courses | Pflichtmodule

Module Description

CS0101: Renewables Utilization | Renewables Utilization

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	**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:
Assessment takes a written examination (90 minutes), with students to unterstand and to apply 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:
Basic lectures in chemistry; Basics on renewables utilization

Content:
Various types of ingredients of renewable raw materials: sugars, polysaccharides, fats and oils, amino acids, proteins, terpenes, aromatics. The following topics will be dealt with in more detail: structure, composition, occurrence, properties, analysis and type of added value or use in various examples.

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:
Lecture and accompanying tutorial including individual work on specific examples.

Media:
Presentation, script, examples and solutions

Reading List:

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

Courses (Type of course, Weekly hours per semester), Instructor:
Renewables Utilization (Exercise) (Übung, 2 SWS)
Rühmann B

Renewables Utilization (Lecture) (Vorlesung, 2 SWS)
Sieber V [L], Rühmann B, Sieber V
For further information in this module, please click campus.tum.de or here.

Module Description

CS0132: Energy Process Engineering | Energy Process Engineering [EPE]

Energy Processes Engineering

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	**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:
Assessment takes the form of a written examination (90 minutes). Students demonstrate their ability to solve basic calculations and apply methods of process technology to different issues. In addition, some questions on energy and process technology plants are to bei answered in a written form.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Technical Thermodynamics

Content:
Within the modul the thermal and chemical components of power plants and process engineering plants such as combustion concepts, fuel treatment, exhaust gas purification, production of fuels from biomass and electricity generation concepts are explained. The basics of the design and calculation of steam generators, reactors and synthesis algae and the treatment of gases from gasification processes and their use e.g. in a fuel cell are explained.

Intended Learning Outcomes:
At the end of the module students can understand complex processes for energy and/or fuel production and are able to detect and explain the required needs (e.g. pressure, temperature) and process technologies.

Teaching and Learning Methods:
The module consists of lectures and tutorials. The contents will bei taught in lectures and presentations.

Media:
Lecture, blackbboard, presentation

Reading List:
Kaltschmitt, M.; Hartmann, H.; Hofbauer, H.: Energie aus Biomasse, 2. Auflage, Springer, ISBN 978-3-540-85094-6, 2009
Spliethoff, H., Power generation from Solid Fuels, Springer, ISBN 978-3-642-02855-7, 2010
Karl, J.: Dezentrale Energiesysteme, Oldenbourg, ISBN 3-486-27505-4, 2004/
Sterner, M.; Stadler, I.: Energiespeicher, Springer Vieweg, ISBN 978-3-642-37379-4, 2014

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

Courses (Type of course, Weekly hours per semester), Instructor:
Energy process engineering (Lecture) (Vorlesung, 2 SWS)
Gaderer M [L], Gaderer M

Energy process engineering (Exercise) (Übung, 3 SWS)
Gaderer M [L], Gaderer M
For further information in this module, please click campus.tum.de or here.

Module Description

CS0133: Mechanical Process Engineering | Mechanical Process Engineering [MVT]

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**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:
Assessment takes the form of a written examination (90 minutes).
The students prove that they can solve computational problems and apply methods of mechanical particles and process engineering as well as answer questions about plants and apparatuses of mechanical process engineering.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Thermodynamics, Reaction Technology, Heat Transfer, Fluid Mechanics

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, scripts, 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:
Gaderer, Matthias; Prof. Dr.-Ing.

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

CS0134: Conceptual Process Design | Conceptual Process Design

Version of module description: Gültig ab summerterm 2024

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

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

Description of Examination Method:
The exam performance is effected by an oral exam. It is reviewed whether the students know the fundamentals of conceptual design of chemical and biotechnological processes and if they can apply this knowledge on the design and evaluation of complex processes. The exam consists of two parts: (a) 30 minutes preparation through solving a given problem set (b) 30 minutes of oral examination. In the beginning of part (b) the results of part (a) are presented by the student. (total duration 60 min)

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Knowleadge of thermodynamics and apparatusses used for fluid sparations processes. It is recommended to visit at least the course "Introduction of Process Engineering" first.

Content:
Basics of cenceptual design of processes; Basics of computational process design including calculation of process parameters; transfer of fundamental scale-up criteria towards real problem solving; Balancing of all process streams; Deepened knowledge of engineering principles.

Intended Learning Outcomes:
The students are qualified to understand the fundamentals of design, calculations, and balancing of chemical processes and fluid separation courses after the course. They will aquire knowledge of different challenges of process design and how to master them.

Teaching and Learning Methods:
The module consists of lectures and parallel tutorials. Contents of the lecture shall be imparted in speech and by presentation. In the exercises performed as part of the module learned theory

shall directly be applied with a practical orientation by means of calculations and examples from targeted aspects of process design and calculation. based on a direct comparison of a chemical process with it´s biotechnical alternative they learn to apply their knowledge on reality based challenges. Additionally they will be qualified by an in-depth knowledge of the design of operation units including calculation of process parameters based on utilization of selected software tools.

Media:
Panel, slides, scripts, practical exercises

Reading List:
Moulijn et al. (2013). Chemical Process Technology. – John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom.
Biegler et al. (1997). Systematic Methods of Chemical Process Design. – Prentice Hall.
Doherty, M.F., Malone, M.F. (2001). Conceptual design of distillation systems. – Boston: McGraw-Hill.
Gmehling, J., Kolbe, B., Kleiber, M., Rarey, J. (2012). Chemical Thermodynamics for Process Simulation. 1. Auflage. Weinheim: Wiley – VCH
Grassmann, P., Widmer, F., Sinn, H. (1997). Einführung in die Thermische Verfahrenstechnik. 3. vollst. überarb. Auflage. Berlin: de Gruyter.
Stichlmair, J.G., Fair, J.R. (1998). Distillation: Principles and Practice. – New York: Wiley – VCH.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Conceptual Process Design (Lecture) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Ibanez M, Staudt J

Conceptual Process Design (Exercise) (Übung, 2 SWS)
Burger J, Rosen N, Wolf A
For further information in this module, please click campus.tum.de or here.

Module Description

CS0135: Cooperative Design Project | Cooperative Design Project

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter 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:
The module concludes with the creation, presentation and positive evaluation of a final presentation. In the presentation, the students should present tasks, solutions, procedures in project management, and the project results in a concise form. The presentation should also show which contributions to teamwork have been made by the students themselves. In regular meetings with the supervisors, the individual achievements will be monitored.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

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, students will be able to
- organize and evaluate the cooperation in a team with heterogeneous knowledge,
- delegate tasks,
- apply the basics of process and energy technology to practical questions,
- design a project in terms of time management, balancing, interaction, objectives,
- analyse projects and to present them to outsiders,
- lead works in a hierarchical organization

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:
Alle prüfungsberechtigten Dozenten/innen des Studienganges Technologie biogener Rohstoffe

Courses (Type of course, Weekly hours per semester), Instructor:
(Cooperative) Design Project (Praktikum, 5 SWS)
Burger J [L], Burger J, Elfaitory H, Rosen N, Staudt J

(Cooperative) Design Project (Praktikum, 5 SWS)
Gaderer M [L], Herdzik S, Huber B, Meilinger S, Putra L, Schenker M, Veiltl P

Cooperative Design Project (Prof. Zavrel) (Praktikum, 5 SWS)
Zavrel M [L], Beerhalter D, Borger J, Dsouza V, Geisler N, Marino Jara J, Oktay I, Stegemeyer U, van der Walt H
For further information in this module, please click campus.tum.de or here.

Module Description

CS0136: Energetic Use of Biomass and Residuals | Energetic Use of Biomass and Residuals [EBR]

Version of module description: Gültig ab winterterm 2020/21

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:
Assessment consists of a written examination (60 minutes) based on the various potential uses of biomass for energy and a presentation on a concept students have developed individually regarding the use of biomass. The written part constitutes 50% of the grade and the presentation as well with 50%.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Technical Thermodynamics, Energy Process Engineering

Content:
Lectures are dedicated to potential technology for using biomass and residuals as a source of energy. In particular, heat generation, energy conversion, power-heat coupling and the process for generating gaseous and fluid sources of energy are discussed. In addition, the generation of biogas (fermentation process) is discussed in detail. However, as there is another lecture dedicated to this topic, this section will be restricted to the technical basics. Practical exercises focus on conception and planningof plants. As part of a seminar, participants should develop voluntary examples and assess these using an economic efficiency calculation. For the tutorial, students work individually in the group on a concept for biomass use. This concept is analyzed in regard to technical and economic feasibility with the result being presented and assessed in a presentation.

Intended Learning Outcomes:
After completion of the module, students are able to evaluate the various systems for use of biomass. They have got a broad overview of options. In addition, they are able to develop a relevant concept, argue in favour of it, and evaluate the economic profit.

Teaching and Learning Methods:
Lecture (talk by teaching staff) with media, tutorial on calculation of examples, presentation of a voluntary concept regarding biomass or residual use.

Media:
Presentation, script, examples, excursion

Reading List:
Script/
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:
Gaderer, Matthias; Prof. Dr.-Ing.

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

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

Electives | Wahlmodule

Technical Electives | Fachspezifische Wahlmodule

Module Description

WZ1240: Advanced Simulation Topics | Fortgeschrittene Simulationsthemen

Version of module description: Gültig ab winterterm 2016/17

Module Level: Master	**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 examination performance is provided in the form of a project work. By working on a more in-depth task, the students demonstrate that they can select and apply methods appropriate to the problem. In the written elaboration, the participants show that they can establish connections, correctly classify facts and adequately present the results achieved.

Repeat Examination:

(Recommended) Prerequisites:
Modules Physics, Mathematics, Simulation and Optimization in Power Engineering, Matlab +Programming Knowledge

Content:
Depending on the topics chosen for the seminar paper, a selection of the following topics will be covered:
advanced concepts of Matlab programming & visualization
- practical modelling & simulation (e.g. motor process simulation, heat conduction equation)
- Import and processing of measurement data
- Advanced simulation and modelling (e.g. neural networks in practice, partial differential equations)
- Deepening theoretical concepts of modelling (e.g., finding nonlinear model parameters, evolutionary algorithms, Fourier analysis, different types of neural networks)

Intended Learning Outcomes:
After participating in the module events, the participants will understand advanced methods for modelling, simulation and optimisation and will be able to select and apply methods appropriate to the problem at hand. The chosen approach and the essential implementation steps are presented and explained in a seminar paper.

Teaching and Learning Methods:
The module includes a seminar part. Here the students work out a solution for a more extensive problem on their own. This usually requires the preparation of more extensive programming tasks and the presentation and justification of the chosen approach in a seminar paper. To support this activity, in the lecture part of the module more in-depth contents are imparted in the lecture and practiced in the exercise part of the module by independent processing of exercises by the students. In the context of the exercise an accompaniment of the seminar work is offered in addition.

Media:
Presentations, slide scripts, blackboard writing, demonstration of programs/scripts

Reading List:
O. Nelles, Nonlinear System Identification, Springer, Berlin, 2010
M. T. Hagan, H. B. Demuth, M. H. Beale, O. De Jesus, Neural Network Design, ISBN 0-9717321-1-6, http://hagan.okstate.edu/NNDesign.pdf+B32

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

CS0003: Production of Renewable Fuels | Production of Renewable Fuels

Version of module description: Gültig ab winterterm 2023/24

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

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

Description of Examination Method:
The learning results are going to be proven in form of a written exam of 90 Minutes. Along the problem set, it is checked whether the student is able to understand, improve and assess industrial processes for the production of renewable fuels. No aids permitted.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge in chemistry, Fundamentals in Thermodynamics (e.g., Grundlagen der Thermodynamik), Fundamentals in Process Engineering (e.g., Introduction to Process Engineering)

Content:
Requirements for fuels, linkage of energetic and chemical value chains, fossil fuel production as reference, balancing and assessments (Well-to-Wheel), Hydrogen and methanol economy, alternative fuels on C1-basis, fisher-tropsch fuels, OME, bio-based oil fuels, biodiesel, green diesel, HEFA, bio-based alcohols, legislation of fuels.

Intended Learning Outcomes:
This module aims at making the students familiar with the industrial processes to produce renewable fuels. They are able to set up material and energy balances of these processes and assess their sustainability. Limitations with respect of raw material supply, energetic efficiencies and market requirements are understood. The students understand the interactions of fuel market and energy market.

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

Media:
Hybrid live lectures & asynchronous mini-videos allowing distance learning, lecture Script and exercises via online platform, excursions to fuel production plants

Reading List:
• Jacob A. Moulijn, Michiel Makkee, Annelies E. van Diepen: Chemical Process Technology, Wiley (2013).
• George Olah et al.: Beyond Oil and Gas: The Methanol Economy, Wiley VCH (2006)
• Volker Schindler: Kraftstoffe für morgen: Eine Analyse von Zusammenhängen und Handlungsoptionen, Springer (1997)
• Martin Kaltschmitt, Hans Hartmann, Hermann Hofbauer: Energie aus Biomasse; Grundlagen, Techniken und Verfahren,SpringerVieweg (2016)
• Jochen Lehmann, Thomas Luschtinetz: Wasserstoff und Brennstoffzellen, Springer (2014)

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

Courses (Type of course, Weekly hours per semester), Instructor:
Production of renewable fuels (Tutorial, Straubing) (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Rosen N

Production of renewable fuels (Tutorial, Garching) (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Staudt J

Production of renewable fuels (Lecture, Straubing) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J

Production of renewable fuels (Lecture, Garching) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J
For further information in this module, please click campus.tum.de or here.

Module Description

CS0012: Artificial Intelligence for Biotechnology | Artificial Intelligence for Biotechnology [AI]

Version of module description: Gültig ab summerterm 2024

Module Level: Master	Language: 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 module examination takes the form of a presentation followed by discussion. The learning outcomes are verified by a group project (3-4 students per group). The presentation of the developed code and the results of the project will be done together as a group, with each group member presenting one part. The presentation should be equally divided among the group members. After the presentation, each group member is asked individual questions about the project. The final grade will be based on the presentation and results of the project (duration of presentation and questions: approx. 30 min depending on group size; approx. 8-10 minutes per student). As a voluntary mid-term effort, the students can take part in a multiple-choice test (duration: 10 minutes). If they achieve at least 65% of the points in this test, a bonus of 0.3 will be credited on the grade of the presantation (however, an improvement of the grade from 4.3 to 4.0 is not possible).

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Mathematical Skills in Linear Algebra and Statistics as well as Programming Skills in Python are expected

Content:
Technologies that generate analyses or predictions based on data can be found in almost all areas of our daily life (e.g. recommender systems, autonomous driving, and credit card fraud detection). These methods are also important for analyzing biological and biomedical data, e.g. for finding novel patterns in biological data, predicting the disease state of a patient, or the 3D structure of proteins. In this course, we will learn the fundamentals of machine learning and will apply these methods to various real-world problems.

The following contents will be treated exemplarily:
- Similarity and Distance Metrics
- Data Preprocessing and Visualization
- Dimensionality Reduction (e.g., Principal Component Analysis)
- Classification (Nearest-Neighbor, Logistic Regression, Decision Trees, Support Vector Machines (SVM))
- Model Selection and Hyperparameter Optimization (Confusion Matrix and Evaluation Measures, Cross-Validation, Hyperparameter tuning techniques, Common problems such as Over- vs. Underfitting)
- Clustering (K-Means, Hierarchical Clustering)
- Regression Models (Linear Regression, Support Vector Regression)

AI-based technologies have the potential to support many areas of biotechnology and sustainability, e.g. by guiding downstream research with data-driven predictions or supporting decision-making with demand forecasts. In this course, we will look at suitable practical examples and demonstrate their potential.

Intended Learning Outcomes:
The students know the fundamental and most important artificial intelligence, especially machine learning, methods and are able to apply them independently on various real-world problems. The students learn the basics of the programming language Python (one of the leading programming languages in the field of machine learning) and are able to implement and apply machine learning algorithms in Python. In addition, students are able to visualize and interpret different types of data and results independently. Students will understand how artificial intelligence can support areas of biotechnology and sustainability and are able to assess the potential of AI-based approaches in sustainability projects.

Teaching and Learning Methods:
Lectures to provide the students with all necessary fundamentals of artificial intelligence, especially of machine learning which they will need to independently apply these concepts to real-world data. In the exercises the students are introduced to the programming language Python, as well as to apply and implement these algorithms for specific case studies.

Media:
The lecture shall mainly be done by using PowerPoint presentations. During the exercise the students work at PCs to gain confidence in using the programming language Python. Students implement various machine learning methods in Python (e.g. using Jupyter Notebooks) and apply them on various examples. Students work on real world problems to implement learnt skills and to gain confidence in applying these different methods independently.

Reading List:
Murphy, K. P. (2012). Machine learning: a probabilistic perspective. MIT press.
Bishop, C. M. (2006). Pattern recognition and machine learning. Springer.
Raschka, S. (2017). Machine Learning mit Python. mitp Verlag.

Friedman, J., Hastie, T., & Tibshirani, R. (2001). The elements of statistical. Springer.

Responsible for Module:
Grimm, Dominik; 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

CS0046: Fundamentals and Technology of Metals | Fundamentals and Technology of Metals [FUNMETAL]

Version of module description: Gültig ab winterterm 2023/24

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

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

Description of Examination Method:
The course will be evaluated in a 90 minute written exam.
In the exam, students shall answer questions freely, or based on sketches. They shall demonstrate that they are able to present production- and property profiles of metallic materials for given applications.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
The module covers the physico-chemical basics of the makeup and the resulting properties of metals. For technologically relevant metals, production routes, testing methods and applications will be shown.

Intended Learning Outcomes:
After completion of the module, students are able to name the technologically most relevant metallic materials. They can evaluate production routes based on their applicability, explain testing methods and name applications of the discussed materials. Through case studies, students are prompted to select materials for specific application scenarios and justify their choice based on manufacturing and property profiles.

Teaching and Learning Methods:
Lecture and Seminar

Media:
Blackboard, slides

Reading List:
Materials Science and Engineering: An Introduction" by William D. Callister Jr. and David G. Rethwisch
"Physical Metallurgy Principles", Fourth Edition, by Reza Abbaschian and Robert E. Reed-Hill

Responsible for Module:
Prof. Marc Ledendecker

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

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

Module Description

CS0058: CFD - Simulation for Energy Systems | CFD - Simulation for Energy Systems [A-CFD]

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**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:
In modern CFD programs, complex mathematical models are made accessible to the user in a simple form. Nevertheless, it is crucial for the correct application of these models to know the basic, theoretical background. The examination performance therefore is a project report. The students prove that they can answer questions about the theory of CFD in writing and solve small computational problems. The students thus show that they are capable of implementing a flow simulation in CFD programs and interpreting the results obtained.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Prerequisites for the successful participation is knowledge about
Fluid Dynamics

Content:
The course provides basic knowledge about the underlying theory of CFD simulation to enable students to conduct simple workflows within the CFD simulation software. Simplifications and models for solving the conversion equations of fluid dynamics - mass, impulse and energy - is shown. Furthermore, meshing and setting up useful boundary conditions for solving the flow equations is presented. After solving the CFD problem, validation and presentation of the results by means of flow profiles and animations will be done. The setup of a CFD model including geometric preparation of a model, meshing, pre-processing, solving, and post-processing will be demonstrated and carried out in the CFD software.

Intended Learning Outcomes:
After successful participation within this course, students are capable of carrying out simple workflows within the CFD simulation software (e. g. OpenFOAM, Ansys), including the preparation of a CAD model, meshing, pre-processing, solving, and post-processing. Furthermore, they gained a basic understanding of the relevant theory behind a CFD simulation software.

Teaching and Learning Methods:
The course is set up of a lecture and practical part. The lecture provides the aforementioned relevant theory underlying a CFD simulation software. The practical part includes a guided setup of a CFD model within the CFD software and an independently conducted project at the end of the semester.

Media:
Lecture, blackboard, computer/laptop

Reading List:
Ferziger, J.H.; Peric, M.: Numerische Strömungsmechanik, 1. Auflage, Springer, eBook ISBN 978-3-540-68228-8, 2008
Gersten, K.: Einführung in die Strömungsmechanik, 2. Auflage, Springer, eBook ISBN 978-3-663-14151-8, 1981
Laurien, E.; Oertel jr., H.: Numerische Strömungsmechanik, 3. Auflage, Springer, eBook ISBN 978-3-658-03145-9, 2013
Ferziger, J.H.; Peric, M.; Street, R.L.: Computational Methods for Fluid Dynamics, 4. Auflage, Springer, eBook ISBN 978-3-319-99693-6, 2019

Responsible for Module:
Matthias Gaderer gaderer@tum.de Bernhard Huber b.huber@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

CS0092: Wind Power | Windkraft [Wind]

Version of module description: Gültig ab summerterm 2024

Module Level: Master	Language: English	Duration: one semester	Frequency: winter semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 82	**Contact Hours:** 38

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

Description of Examination Method:
The basics of energy generation from wind are assessed in a written examination (60 minutes). Multiple-choice questions can also be asked. The students prove that they have understood the technology of wind turbines and that they are able to carry out calculations on the design, energy yield and economic efficiency of wind turbines. They also show that they have understood the special problems in the project planning phase as well as during operation within the framework of legal requirements, the requirements for nature and species protection as well as the local acceptance of wind power use and ecology and acceptance and that they are able to evaluate plants and sites in this respect.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basics in Mathematics and Physics
Basics in Energy Technology

Content:
This module teaches in-depth knowledge about energy generation from wind power. The technology is described using the following points:
- Physical basics
- Designs and system components
- Planning, construction and operation
- Power output and energy supply
In addition to the technical characteristics of the plants, the module also focuses on their effects on the environment, legal framework conditions and economic

Intended Learning Outcomes:
Having attended the module, the students will be able to characterize and recognize different types of wind turbines and to understand them from a technical and energetic point of view. The students understand the processes involved in planning, erecting and operating wind turbines and are able to evaluate turbines from an economic and ecological point of view.

Teaching and Learning Methods:
The module consists of lecture and exercise. The contents of the lectures are primarily conveyed by the lecturers and through presentations. The students should get a well-founded insight into the topic. The exercises cover on the one hand technical calculations on wind turbines, on the other hand the different aspects of turbine project planning, in particular economic and ecological aspects, as well as acceptance by public. Among other things, plan and role plays in groups are planned to achive this goal. Some of the exercises are to be prepared by the students themselves, others are to be carried out as face-to-face exercises. This should encourage students to work independently and to deal more intensively with the respective topics. Simulation and role-playing games help students to gain a deeper understanding of the opportunities and problems in the field of wind power technology.

Media:
PowerPoint, blackboard, publications

Reading List:
Peter Schaffarczyk, Wind Power Technology, Springer, 2023, ISSN 1865-3529, ISSN 1865-3537 (electronic)

Responsible for Module:
Doris Schieder Doris.schieder@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Windkraft Übung (Übung, 1 SWS)
Schieder D [L], Schieder D, Widmann A

Windkraft Vorlesung (Vorlesung, 1,5 SWS)
Schieder D [L], Schieder D, Widmann A
For further information in this module, please click campus.tum.de or here.

Module Description

CS0100: Microbial and Plant Biotechnology | Microbial and Plant Biotechnology [MPBioTech]

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**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 order to check whether students have understood and are able to apply the principles and relevant methods and techniques of biotechnological production processes, the students answer questions about production processes and fermentation strategies, as well as on important methods and applications in plant biotechnology in a written exam (90 min) and prove that they have understood the correlations of metabolism. Allowed tools are calculators.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamentals of Biology or of cell and microbiology from the Bachelor's courses

Content:
In the lecture microbial biotechnology relevant topics and techniques of microbial biotechnology are presented. This includes the quantitative description of the metabolic performance of microorganisms, industrially relevant substrate sources, metabolic engineering strategies as well as examples of industrial production processes (e.g.: alcohols, amino and organic acids).
In the lecture plant biotechnology the most important model and crop plants in biotechnology are presented, classified and their morphological and physiological properties are emphasized. Major questions, methods and solutions will be discussed with thier pros and cons. Some of the topics to be discussed: legal framework, major appilcation of current plant genetic engineering, the Arabidopsis model system, snovel concepts for yield and quality improvement. One focus is on the challenges for agriculture caused by climate change and sustainable solutions.

Intended Learning Outcomes:
Upon successful completion of the module, students will be familiar with the principles and techniques of relevant microbial bioprocesses. The students have acquired knowledge of fermentation processes and are able to develop strategies for process control for selected product classes. The students have learned to quantitatively describe microbial growth and fermentation processes. The students have acquired in-depth knowledge of relevant production processes for selected products of industrial biotechnology and understand their importance for the development of sustainable chemistry. Also, the students know the most important methods and applications in plant biotechnology and are able to assess them.

Teaching and Learning Methods:
The contents of the lectures are conveyed by a talk of the lecturer, based on PowerPoint presentations. The blackboard might additionally be used to explain more complex relationships. To a limited extent, this can be supplemented by self-study of the literature mentioned in the lecture.

Media:
PowerPoint, whiteboard

Reading List:
Microbiology – an evolving science, J. L. Slonczewski, J. W. Foster, W W Norton & Co Inc, 4th edition, ISBN: 978-0-393-61403-9 (available in the library)
Molecular Biology of the Gene, I. D. Watson, T. A. Baker, A. Gann, M. Levine,
Losick, Pearson, 7th edition, ISBN-13: 978-0321762436 (available in the library)
Biotechnology, R. D. Schmid, C. Schmidt-Dannert, Wiley-VCH, 1st edition,
ISBN: 978-3-527-33515-2 (available in the library, eBook)
Industrial Microbiology, D. B. Wilson, H. Sahm, K.-P. Stahmann, M. Koffas,
Wiley-VCH, 1st edition, ISBN: 978-3-527-34035-4 (available in the library)
Industrial Biotechnology – Products and Processes, C. Wittmann, J. Liao,
Wiley-VCH, volume 4, ISBN: 978-3-527-34181-8 (available in the library, eBook)
Industrial Biotechnology – Microorganisms, C. Wittmann, J. Liao,
Wiley-VCH, volume 4, ISBN: 978-3-527-34179-5 (available in the library, eBook)
Campbell Biology N. A. Campbell, L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, J. B. Reece, Pearson, 11th edition (2018) (available in the library)

Responsible for Module:
Blombach, Bastian; Prof. Dr. rer. nat.

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

Applied Microbiology and Metabolic Engineering (Lecture) (Vorlesung, 2 SWS)
Blombach B [L], Blombach B, Glawischnig E

Plant Biotechnology (Lecture) (Vorlesung, 2 SWS)
Glawischnig E [L], Glawischnig E
For further information in this module, please click campus.tum.de or here.

Module Description

CS0105: Modelling and Optimization of Energy Systems | Modelling and Optimization of Energy Systems [MOES]

Version of module description: Gültig ab winterterm 2023/24

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

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

Description of Examination Method:
Assessment is done in a written examination (90 minutes). Participants of the course solve programming tasks to demonstrate that they are able to apply the methods aquired in the course. By answering questions related to case examples they show that they have learned to put things into their proper context.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Bachelor modules Mathematics, Physics, Numerical Methods;
Basic knowledge in Energy technology; basic programming experience (ideally with Matlab)

Content:
Basics of Modelling and Simulation:
- physical models
- data-based models (look-up tables, polynomials, neural networks)
- methods for generating models
Fundamental optimization methods:
- linear optimization (linear regression)
- nonlinear optimization

Intended Learning Outcomes:
After attending the course the participants understand basic methods for creating models, simulation and optimization. In addition, they are able to apply these methods by creating appropriate program code in Matlab. Furthermore, the participants acquire Matlab programming experience.

Teaching and Learning Methods:
The module consists of a lecture and an excercise. Lectures include presentations whose content is deepened by solving excercise problems autonomously. In order to improve the learning outcome, participants work at homework excercise problems. These are discussed in the next lecture.

Media:
PP presentation, whiteboard, demonstration of programs

Reading List:
S. R. Otto & J.P. Denier, An Introduction to Programming and Numerical Methods in MATLAB, Springer, London, 2005
O. Nelles, Nonlinear System Identification, Springer, Berlin, 2010

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

Courses (Type of course, Weekly hours per semester), Instructor:
Modelling and Optimization of Energy Systems (Vorlesung mit integrierten Übungen, 4 SWS)
Kainz J [L], Kainz J
For further information in this module, please click campus.tum.de or here.

Module Description

CS0109: Sustainable Energy Materials | Sustainable Energy Materials
[SEM]

From the basics to the application

Version of module description: Gültig ab summerterm 2023

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:
The learning outcomes will be checked through a written exam (90 minutes) in which the students have to reproduce essential aspects of sustainable energy materials and their applications through examples. In addition, mathematical problems will be given to show that the students are able to quantify simple examples.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of basic electrochemistry/physical chemistry is beneficial, but not required.

Content:
Sustainable energy management is an important issue to minimize environmental impact and climate change. Electrochemical devices such as fuel cells and batteries can help use Renewable In this course, you will learn about the basics of electrochemistry and various important devices used in current and future energy systems, such as fuel cells, batteries, and electrochemical water splitting. The lectures will cover the working principles, components, materials, applications, and future potential of these devices in the energy economy.
Using catalysts in chemical reactions can increase their speed and selectivity, leading to significant energy savings. One section of the course will focus on fuel cell catalysis, and other ideas such as using catalysts in chlorine electrolysis will be introduced to demonstrate how choosing the right counter reaction can result in energy efficiency. The topic of water splitting to obtain hydrogen will be covered later in the course.
We will examine the use of different materials in energy-related devices and how their electronic and ionic properties affect their performance.

Batteries play a crucial role in electromobility by efficiently storing and releasing electrical energy. One part of the course will cover Li-ion batteries, starting with an overview of their fundamentals and the most common cell types. In addition to discussing the characteristics of typical Li-ion electrode materials and electrolytes, the course will show how key performance characteristics such as energy density, power density, and lifespan are influenced by the cell chemistry. The course will also introduce concepts for the next generation of batteries, such as all-solid-state batteries.

Intended Learning Outcomes:
Upon successful completion of this course, students will be able to:
1. Understand and Explain Key Concepts in Electrochemistry:
o Remember and describe the fundamental principles of electrochemistry, including thermodynamics, kinetics, Pourbaix diagrams, and the Butler-Volmer equation.
o Explain the significance of electrochemical processes in energy conversion and storage technologies.
2. Analyze Electrochemical Systems:
o Interpret Pourbaix diagrams to determine the stability of materials in various pH and potential conditions.
o Apply the Butler-Volmer equation to analyze the kinetics of electrochemical reactions in different energy systems.
o Evaluate the thermodynamic feasibility of electrochemical reactions in sustainable energy applications.
3. Comprehend and Apply Battery Fundamentals:
o Understand the working principles of batteries, including charge/discharge processes, energy density, and power density.
o Differentiate between various battery types (e.g., lithium-ion, sodium-ion, solid-state, flow batteries) based on their materials, design, and application potential.
o Apply knowledge of battery chemistry to assess the performance and suitability of different battery types for specific sustainable energy applications.
4. Develop and Evaluate Sustainable Battery Solutions:
o Develop strategies for improving the efficiency, lifespan, and environmental impact of existing battery technologies.
o Critically evaluate the potential of emerging battery materials and technologies for future energy storage solutions.
5. Understand and Analyze Hydrogen Fuel Cells:
o Explain the principles of hydrogen fuel cells, including the role of catalysts, membrane technology, and the overall electrochemical process.
o Analyze the efficiency and challenges associated with hydrogen fuel cells in comparison to other energy conversion technologies.
o Evaluate the environmental and economic implications of hydrogen fuel cell deployment in various sectors.
6. Comprehend and Apply Knowledge of Electrolyzers:
o Understand the operation of electrolyzers, particularly in the context of hydrogen production from renewable energy sources.

7. Integrate Knowledge to Develop Sustainable Energy Solutions:
o Synthesize knowledge from electrochemistry, battery technology, and hydrogen energy systems to propose innovative solutions for sustainable energy storage and conversion.
o Critically evaluate the trade-offs between different energy materials and technologies, considering factors such as cost, scalability, environmental impact, and performance.
These learning outcomes are designed to ensure that students not only grasp the theoretical concepts of sustainable energy materials but also apply and evaluate these concepts in practical, real-world contexts.

Teaching and Learning Methods:
The module consists of a lecture with integrated exercises. The learning content is conveyed through lectures. In the integrated exercises, students work on individual questions and present their solutions.

1) Lectures:
- Purpose: Lectures provide the essential theoretical foundation in sustainable energy materials, covering key topics like basic electrochemistry, battery fundamentals, and hydrogen fuel cells.
- Approach: Interactive and structured with clear explanations, visual aids, and real-world examples, lectures often include brief in-class exercises to reinforce understanding.
- Outcome Alignment: Lectures support learning outcomes related to understanding and explaining core concepts, while integrated exercises help students begin to apply and analyze these ideas.

2) Exercises and Problem-Solving Sessions:
- Purpose: These sessions reinforce lecture material, allowing students to practice problem-solving, apply theory to real-world scenarios, and deepen their understanding.
- Approach: A mix of individual and collaborative exercises, including problem sets, with guidance from instructors to support learning.
- Outcome Alignment: Exercises align with outcomes related to applying, analyzing, and evaluating knowledge, preparing students for advanced tasks in projects and labs.

Media:
1) Presentation Slides:
• Purpose: Presentation slides will be the primary medium for delivering content during lectures. They will be designed to visually complement the spoken content, providing clear and concise explanations of key concepts, diagrams, equations, and real-world examples.
• Usage: Slides will be used to illustrate complex ideas in electrochemistry, battery technology, and hydrogen systems, helping students to follow along and understand the material more effectively. Key points, equations (e.g., Butler-Volmer equation), and visual aids (e.g., Pourbaix diagrams) will be highlighted to enhance comprehension.
• Accessibility: All slides will be made available to students before or after the lectures via the course's online platform, allowing for review and study at their own pace.
2) Online Learning Platform:

• Purpose: The online learning platform (e.g., Moodle, Blackboard) will serve as the central hub for course materials, communications, and assessments. It will facilitate a blended learning approach, integrating various media forms into a cohesive learning experience.
• Usage: The platform will host lecture slides, videos, reading materials, quizzes, and assignments. It will also be used for discussion forums where students can ask questions and engage in peer learning. This platform supports continuous access to resources and enables students to manage their learning effectively.
• Interactivity: Features such as quizzes, polls, and discussion boards will allow students to interact with the material and with each other, enhancing engagement and reinforcing learning.
3) Textbooks and Research Articles:
• Purpose: Textbooks and scholarly articles provide in-depth coverage of theoretical concepts and the latest research developments in the field. These resources are essential for supporting lecture content and offering additional perspectives on topics covered in the course.
• Usage: Core textbooks will be recommended for fundamental concepts, such as basic electrochemistry and battery technology. Research articles will be assigned to provide insights into recent advancements and emerging trends in sustainable energy materials. These readings will complement lecture content and form the basis for exercises and discussions.
• Depth: By engaging with these texts, students will deepen their understanding of the material and develop critical thinking skills, particularly in evaluating new research and technological developments.

Reading List:
Handbook of fuel cells, Wolf Vielstich, Hubert A. Gasteiger, Arnold Lamm, 2010
Electrochemical Systems, Karen Thomas-Alyea, John E. Newman, 2021

Responsible for Module:
Ledendecker, Marc; 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

CS0125: Plant and Technology Management | Plant and Technology Management [PTM]

Version of module description: Gültig ab winterterm 2020/21

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:
Written exam (90 minutes): By solving problems from the thematic field of the module students have to prove their understanding of the management of industrial plants and technologies, their ability to techno-economic assessment and optimization methods and their analytical and verbal skills in the field. In the solution of the problems they need to demonstrate their ability to analyse technical systems, assess them from an economic point of view and apply techno-economic methods to solve planning and optimization problems arising in the life cycle of these plants.
In addition, they need to show that they are able to discuss the application of these methods in practice and to derive further research needs. Learning aids: pocket calculator.

Alternative: For smaller groups (<15 students) parts of the examination can be held in form of a case study. In this case studies, students have to demonstrate in a group work that they acquired the above mentioned abilitites by solving problems of practical relevance. This acknowledges the complexity of real world problems and the necessity to solve these in (interdisciplinary) team works. With the case study solution students have to provide a statement of the individual contributions to the solutions. Weighting: 1:1.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
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Content:
The module contains units covering the following topics:
• Introduction to Plant and Technology Management
• Life cycle of industrial plants

• Analysis and modelling of industrial production systems
• Project management in engineering
• Network and facility location planning
• Investment estimation
• Cost estimation
• Plant and process optimisation
• Maintenance and repair
• Quality Management
• Re-location, dismantling and recycling

Intended Learning Outcomes:
The students are able to solve techno-economic analysis, planning, and optimisation problems associated with the life cycle of industrial plants. This comprises also linked topics of technology assessment and management. After completion of this module the students are able to identify and characterise these problems and structure them. Further, they are able to determine needed data and apply suitable methods for the solution of the problems. They discuss the achievements and shortcomings of these methods for a practical application. They are able to transfer these contents to an application in practice.

Teaching and Learning Methods:
Format: Lecture with tutorial to introduce, train and deepen the contents of the module.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies with presentation
- Individulal assignments and presentation
The teaching and learning methods are combinded specifically for the treated topics. Typically, a thematic impulse or overview is given with a media-assisted presentation. Individual or group work assignments provide the possibility to apply the acquired competencies, to repeat and deepen these as well as to prepare the transfer to other fields.

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

Reading List:
Empfohlene Fachliteratur:
1. Chauvel (2003): Manual of Process Economic Evaluation, Edition Technip
2. Couper (2003): Process engineering economics, Marcel Dekker Inc
3. Geldermann (2014): Anlagen- und Energiewirtschaft
4. Goetsch/Davis (2015): Quality Management for Organizational Excellence: Introduction to Total Quality, Pearson
5. Mobley/Higgins/Wikoff (2014): Maintenance Engineering Handbook, McGrawHill
6. Peters/Timmmerhaus/West (2003): Plant Design and Economic for Chemical Engineers, McGrawHill

Weitere Literaturempfehlungen werden in den Veranstaltungen gegeben.

Responsible for Module:
Magnus Fröhling

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

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

Module Description

CS0138: Research Lab Energy and Process Engineering | Research Lab Energy and Process Engineering

Version of module description: Gültig ab winterterm 2020/21

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

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

Description of Examination Method:
In the practical course, the exam is taken by positively elaborated written internship reports. 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 experiments with technical plants in small groups.

Repeat Examination:
Next semester

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

Content:
Experimental methods used in research. These include e.g. phase equilibrium measurements, elucidation of reaction kinetics, classification of particle sizes.

Intended Learning Outcomes:
After graduation of the practical course, the students are able to independently design, execute, and evaluate research experiments in energy and process engineering (for exampel in reaction engineering or separation science).

Teaching and Learning Methods:
The acquisition of the basics is to be prepared by the literature handed out. Under supervision, students plan experiments to solve given problems. They will be supported and supervised by laboratory personnel during the setup and execution of the experiments.

Media:
Practical course script, laboratory equipment

Reading List:
Practical course script

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

Courses (Type of course, Weekly hours per semester), Instructor:
Research Lab Energy and Process Engineering (Praktikum, 5 SWS)
Gaderer M [L], Fang W, Gaderer M (Burger J, Kainz J), Huber B, Meilinger S, Schenker M, Veiltl P
For further information in this module, please click campus.tum.de or here.

Module Description

CS0139: Flowsheet balancing and simulation | Flowsheet balancing and simulation [ABS]

Version of module description: Gültig ab winterterm 2020/21

Module Level:	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 is performed in the form of a seminar paper, in which an energy-technical task is to be solved with the software program. The learning result is checked by the way the work is carried out within the scope of the examination and the result achieved. The students prove that they can solve balancing tasks by using the software. It is proven that the students have understood the principles of balancing.

Repeat Examination:

(Recommended) Prerequisites:
Basic knowledge of the most important physical relationships (basic quantities with units, definition of pressure, temperature, enthalpy, entropy, etc.) must be available. Furthermore, the establishment and solution of mathematical systems of equations as well as the mastery of simple integral and differential calculus are assumed. Knowledge of mathematics, thermodynamics, energy and process engineering are required.

Content:
In this module, knowledge of the application of a selected software program (e.g. Aspen) for the calculation and design of energy engineering tasks is taught.
The selection of the software is based on the availability of the program and the availability of a teacher with the technical knowledge of the program.

Intended Learning Outcomes:
After the participation in the module the students are able to understand simple tasks for the calculation of energy systems with the software program, to build up, define and solve them in the used program environment (Aspen).

Teaching and Learning Methods:
The module consists of a seminar, because this form of learning is best suited for the introduction to software. The introductions take place in short presentations, which are followed by direct working with the program.

Media:
Presentations, slide scripts, program exercises

Reading List:

Responsible for Module:
Matthias Gaderer gaderer@tum.de Christian Schuhbauer schuhbauer@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

CS0140: Advances in Bioprocess Engineering | Advances in Bioprocess Engineering [ABE]

Advances in Bioprocess Engineering

Version of module description: Gültig ab summerterm 2023

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

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

Description of Examination Method:
The learning outcomes are evaluated by a graded seminar presentation. The prsentation allows the students to assess the extent to which they can summarize a complex scientific work in the field of Bioprocess Engineering correctly and present it to an audience in a comprehensible and convincing way.

Repeat Examination:

(Recommended) Prerequisites:
Modules: Bioprocess Engineering, Downstream Processing, Conceptual Design of Bioprocesses

Content:
The technical content of the course focuses on current research results in the field of Bioprocess Engineering (Fermentation, Downstream Processing, Scale-up). This seminar focuses on particularly sustainable bioprocesses that, for example, use agricultural residues, are less harmful to the environment or protect the climate.

Intended Learning Outcomes:
The students know the current and relevant methods and applications of Bioprocess Engineering and are able to evaluate and classify them. Students can acquire, present and critically discuss relevant technical literature.

Teaching and Learning Methods:
First, a selection of current publications is made and a preliminary discussion of the respective topics with the students takes place. The students then work out a presentation which they then present and discuss in the seminar.

Media:
presentations, publications

Reading List:
will be given out at the start

Responsible for Module:
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

CS0142: Detail Process Engineering | Detail Process Engineering [DPP]

Version of module description: Gültig ab winterterm 2022/23

Module Level: Master	**Language:** 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 examination is provided in the form of a term paper.
The students prove that they can solve specific tasks and computational tasks and apply methods of plant planning and safety analysis and answer them in writing.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Mechanical process engineering, materials engineering, mechanics

Content:
The module teaches the usual components used in plant engineering, such as machines, pipelines, valves, actuators and apparatus, and their function. Building on this, an introduction to safety and emission-relevant design guidelines such as e.g. steam boiler regulations, AD2000 leaflets, ASME, TA Luft and BimschV is given. As part of exemplary small-scale plant planning, specifications for media, machines, apparatuses and plants are drawn up and security analyzes are carried out. Their results are incorporated in the planning process. A key focus of the module concerns the practice-oriented aspect of technical plant safety as well as requirements within the scope of a CE certification in plant construction.

Intended Learning Outcomes:
After completing the module, students will be able to describe technical equipment components, perform apparatus design in terms of material, pressure, temperature, process demand according to AD2000 data sheets and steam boiler regulations, specifications for media, equipment and apparatus, VDI, DIN, To apply EN standards to the TA Luft and Bimsch laws and regulations, to describe the course of an ASME code, to describe the content and course of CE certification and

construction products, to apply system-related hazard and safety analyzes and safety-related solutions - for example by control technology Aspects - to be included in a plant design.

Teaching and Learning Methods:
The module consists of Lecture and Exercise.
In the lecture, the contents of the lectures will be conveyed during lectures and presentations. The students are encouraged by the seminar paper to actively engage with the topics.
The exercises serve to strengthen the comprehension of the teaching contents. For this exercise examples are processed.

Media:
Presentations, scripts, exercises

Reading List:

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

CS0143: Hydropower | Wasserkraft [HyPo]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**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 basics of energy generation from hydropower are assessed in a written examination (60 minutes).

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basics in Mathematics and Physics
Basics in Energy Technology

Content:
"In-depth knowledge regarding energy generation from water power is taught in this module. The technologies used for this purpose will be presented from the following points of view:
• Physical basics
• construction types and system components
• Planning, erection and operation
• Power output and energy supply
In addition to technical features of plants, their effects on the environment as well as sustainability considerations are covered. Legal framework conditions as well as the economic aspects of using water power are discussed as well. "

Intended Learning Outcomes:
After completion of the module, students are able to characterize various types of plants for the use of hydropower. They can recognize and understand the plants from the point of view of energy and technology.

Teaching and Learning Methods:
The module consists of a lectures with integrated excercises. Lectures include talks and presentations as well as exercises. Students should be encouraged to study the literature and discuss about the topics. In addition, practical excercises with measurement equipment and an excursion may be included.

Media:
PowerPoint
Blackboard

Reading List:
Jürgen Giesecke, Emil Mosonyi: Wasserkraftanlagen. Springer, 2009. ISBN 978-3-540-88988-5

Responsible for Module:
Prof. Josef Kainz

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

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

Module Description

CS0147: Energy Efficient Buildings | Energy Efficient Buildings [EEB]

Version of module description: Gültig ab winterterm 2022/23

Module Level: Master	**Language:** 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:
Students demonstrate their knowledge and understanding of the differenct aspects of energy efficient buildings in form of a written examination (90 minutes). Students deliver definitions, describe and outline relevant processes, mechanisms and requirements of energy efficient buildings. Furthermore, students calculate different technical specifications and parameters based on provided practice-oriented examples.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basics of physics, Basics of energy technology

Content:
The course focuses on the variety of options for implementation and/or enhancement of energy efficiency in new and existing buildings. This includes an introduction to relevant expert knowledge of energy and ressource efficient building materials and construction. In addition, typical measures for the enhancement of energy efficiency in existing buildings will be presented and evaluated concerning ther sustainability. The second part of the module is concerned with renerwable energy based systems for heat and warm water provision of buildings. Specific advantages and disadvantages of the presented technologies will be discussed in regards to building and usage type. In addition to the presentation of individual measures, it will be analyzed how concepts for energy efficient buildings can be include in modern building infrastructure and on living quarter scale.

Intended Learning Outcomes:
"After successful completion of the module, students acquire in-depth understanding of factors determining the energy efficiency of buildings and relevant legal requirements. Students can

evaluate the sustainability of actions to enhance the energy efficiency of (existing) buildings. In addition, students can understand as well as evaluate and explain advantages and disadvantages of systems for heat and warm water provision based on renewable energies in regards to building and usage type.

Students prepare short, practice-oriented tasks as homework 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 passed on to the other participants accordingly with the focus on sharing results in the form of a written report as well as team work.

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

Media:
PowerPoint, blackboard, videos

Reading List:
Bauer, M., Mösle, P., Schwarz, M. (201.): Green Building: Leitfaden für nachhaltiges Bauen. Springer Vieweg. Daten von Fachagenturen: BINE Informationsdienst, vom Bundesumweltministerium bzw. entsprechenden Landesministerien und anderen internationalen Organisationen.

Responsible for Module:
Vienken, Thomas; 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

CS0148: Measurement, Testing, Modeling | Measurement, Testing, Modeling

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** 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:
Examination in form of a final presentations (25% of the total grade) of the task of the individual groups and a written documentation report (75% of the total grade) of the group work. The report will have 4 to 5 pages per student. Students will prove their understanding and autonomous application of the teaching content (formulation and testing of hypotheses).

Repeat Examination:

(Recommended) Prerequisites:
Basics of physics
Basics of measurement technology

Content:
The course focuses on planing and conduction of laboratory or field experiments of applied energy and environmental research, e.g. ground water heat transport and heat storage. Therefore, the module starts with an introduction to relevant underlying technical and natural science contents. Students will work on an assigned practice-oriented tasks in the further module. Students will in groups formulate working hypotheses to solve these tasks and will test the hypotheses by means of laboratory or field experiments. These experiments will be planned and conducted autonomously by students. Planing process includes modeling of respective experiments via existing analytical or numerical (using simulation software) solutions. Students will be able to use existing sensors for the eperiments or design basic measuring devices on their own. Students will critically evaluate obtained results (modeling and measurement results) and identify and quantify resulting uncertainties. Individual groups present results of their task and work approach as well as obtained results to the other students. Thereby, students will learn to critically question scientific questions and concepts.

Intended Learning Outcomes:
After successful completion of the module, students acquire in-depth understanding of formulating scientific hypotheses in regards to scientific questions. Students obtain skills to test these hypotheses using laboratory and field experiments. Students will be able to plan, this includes modeling of expected results via existing analytical or numerial solutions, and to conduct basic scientific experiments. Students will be able to critically evaluate measurement data and underlaying scientific concepts and present this to a group.

Teaching and Learning Methods:
After an introductory lecture, groups of students will review textbook and non-traditional textbook literature, e.g. tutorials and teach relevant aspects for their work between groups. Thereby, students take responsible to teach relevant content to peers.

Media:

Reading List:
Eden, K., Gebhard, H. (2014): Dokumentation in der Mess- und Prüftechnik. Springer Vieweg.
Daten von Fachagenturen: BINE Informationsdienst, vom Bundesumweltministerium bzw. entsprechenden Landesministerien und anderen internationalen Organisationen.

Responsible for Module:
Prof. Thomas Vienken

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

CS0228: Technology and Management of Renewable Energies in a Global Context | Technology and Management of Renewable Energies in a Global Context [REAE]

Version of module description: Gültig ab summerterm 2024

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

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

Description of Examination Method:
The exam will be in form of an oral presentation of the students (20+10 minutes; 75% of the grade) and a short report of the students' project work (max. 5 pages, not counting front page and cited literature; 25% of the grade).

In this students' project, the students demonstrate understanding of specific questions related to a defined topic concerning the technology and management of renewable energies in a global context. Students have to show in their presentation that they can analyse, solve and answer defined problems and questions related to this topic. Participants of the course show that they have done appropriate research work and are able to present their results. By answering follow-up questions related to their presentation they show that they have learned to put their research outcome into the relevant technical or country context. The presentation slides and the short report will be handed over to the lecturers and will be included in the grading.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic know-how related to specific techniques of renewable energies (e.g. solar energy, wind energy, hydropower, biomass conversion technology, geothermal energy) as well as management of energy systems either on a company or on state level.

Content:
A) Technical aspects of different forms of renewable energies (e.g. current state of technology, technical options for the future, technical bottlenecks, scale-up possibilities)
- Wind power

- Hydropower
- Photovoltaics, solarpower
- Geothermal energy
- Biomass use for energy purposes
- Biofuels, electric vehicles, E-fuels
- Hydrogen
- Other forms of renewable energies

B) Economic aspects related to defined renewable energies (e.g. cost of use/production, cost structure and development in the past, learning curves, innovation and diffusion of renewable energies)
C) Influencing factors for adoption and use of renewable energies (e.g. natural/local conditions, availability of renewable resources, technical infrastructure, user structure of energy, cost and economic factors, financing, political and regulatory issues, social acceptance, behaviour of stakeholders and people)
D) Situation and development in a specific (country) context (e.g. governance, policy goals and activities, competing factors and interests (e.g. by fossil energy use or related companies/ stakeholders), legal and regulatory stability)

Intended Learning Outcomes:
At the end of the module, students will be able to analyse and elaborate solutions for existing problems related to the technology and management of renewable energies and apply such solutions to the specific context of selected countries worldwide. They consider both the technical side as well as the economic and management dimension in order to develop integrated solutions for a specific question related to renewable energies. Additionally they take the specific context and situation (e.g. technical infrastructure and know-how, maintenance, electrical or other grids, political and regulatory rules, economic framework, company and user structure) in one or several countries or regions into account when analysing and elaborating solutions for the question on-hand. They are able to apply their knowledge to create an oral presentation and a written summary of their findings. Presented results are discussed with the audience so that students are able to defend their solution and put it in an appropriate context.

Teaching and Learning Methods:
The module is a seminar, where course participants form (preferably international) teams that investigate a given topic by autonomously doing research work and discussing results within the team. During regular meetings with the lecturers questions can be discussed, next steps are defined and (interim) results are presented. Lecturers will provide basic and background material for the students as well as actual information for the given topics that are elaborated by the student teams.

Learning activities: Literature/document research, student group project

Media:
Presentation slides, online discussion forum (all lecture materials are available via Moodle)

Reading List:
Specific literature and documents will be provided to the topics that are worked on in the student projects

Responsible for Module:
Menrad, Klaus; Prof. Dr.sc.agr.

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

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

Module Description

CS0245: Advanced Electronic Spectroscopy | Advanced Electronic Spectroscopy

Version of module description: Gültig ab summerterm 2022

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

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

Description of Examination Method:
The performance test will be in the form of a written examination. The students should demonstrate in the exam the understanding of the different techniques taught during the module.
No auxiliary means are allowed in the exam. 120 min examination time

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
This course will intend to consolidate concepts in Physics, Chemistry, and Instrumentation having the focus on articles utilizing the different techniques. As such, knowledge in Physics, Chemistry, and Instrumentation is required.

Content:
The module aims to provide in-depth knowledge to the students in electronic spectroscopy and its applications.
The module will critically evaluate optical spectroscopy techniques such as fluorescence, Uv-Vis absorption, Circular dichroism, photoacoustic spectroscopy, and circularly polarized luminescence focusing on their fundamental strength and weakness. Every method will be described following three main focuses: theory, material description, and applications.
Application examples will be from literature and journal articles.
The module will also continuously reinforce the theoretical background of the interaction between electromagnetic radiation and matter.

Intended Learning Outcomes:
At the end of the module, the students will have developed the ability to analyze advanced problems in electronic spectroscopy and associated phenomena. They will learn to evaluate

critically information regarding techniques such as fluorescence, Uv-Vis absorption, Circular dichroism, photoacoustic spectroscopy, and circularly polarized luminescence.

Teaching and Learning Methods:
This course attendance includes lectures and exercises. Additionally, in the module's final weeks, the student will be encouraged to create a presentation consisting of their critical analysis of a journal article. For this purpose, PowerPoint presentations, practical training materials, and open discussion seminars will be used.

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

Reading List:
1. Physical Chemistry for the Life Sciences, 2ndEdition Peter Atkins and Julio De Paula Oxford University Press ISBN: 978-0-19-956428-6
2. Introduction to Biophotonics Paras N. Prasad Wiley 2003, ISBN: 0-471-28770-9.
3. Principles of fluorescence spectroscopy , Lakowicz, Joseph R., ed. . Springer science & business media, 2013.

Responsible for Module:
Costa Riquelme, Rubén Dario; 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

CS0255: Current Topics in Machine Learning and Bioinformatics | Current Topics in Machine Learning and Bioinformatics [CTMLBI]

Version of module description: Gültig ab summerterm 2023

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

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

Description of Examination Method:
The learning outcomes are tested by a graded seminar presentation with a duration of approximately 45 minutes including a discussion with the audience. The seminar allows the students to assess the extent to which they can summarize a complex scientific work in the field of Machine Learning or Bioinformatics correctly and present it to an audience in a comprehensible and convincing way. Furthermore, to assess the skill to quickly understand, review and critically discuss recent research in these fields, the active participation and discussions of the other seminar presentations will be considered as well.

Repeat Examination:

(Recommended) Prerequisites:
Knowledge in Machine Learning and Bioinformatics (e.g. Bioinformatics (WZ1631) and Artificial Intelligence for Biotechnology (CS0012)) is expected

Content:
At the beginning of this course, introductory lectures about current topics in Machine Learning and Bioinformatics will be given. The following topics are treated exemplarily:
- Ensemble learners
- Neural Networks (Basic concept, Feedforward neural networks, Recurrent Neural Networks, Convolutional Neural Networks, Generative Models)
- Green Artificial Intelligence
- Genome-wide Association Studies
- Phenotype Prediction
- Protein-Protein Interaction Network Analysis
- Protein Prediction

- Data Driven Biotechnology
In this course, we will also talk about recent Machine Learning and Bioinformatics research and how it can support sustainability, e.g., by guiding downstream research with data-driven approaches. Furthermore, we will also look at Green Artificial Intelligence, a research direction that aims to make resource-intense AI development more sustainable. After introductory lectures, each student will analyze a recent scientific paper in these research areas in self-study and present it to the course. Active participation and discussions in all the other presentations is expected.

Intended Learning Outcomes:
After successful participation in this module, students will be able to understand and present recent research in Machine Learning or Bioinformatics. They are enabled to analyze recent scientific publications in one of the two fields. Based on this knowledge, they can summarize and present a scientific paper in a concise and understandable way as well as to discuss recent research in Machine Learning or Bioinformatics. Furthermore, students know about current research directions in these scientific fields and know how current Machine Learning and Bioinformatics research supports sustainability.

Teaching and Learning Methods:
At the beginning of this course, introductory lectures to current Machine Learning and Bioinformatics topics will provide additional and necessary fundamentals to understand recent scientific publications. Furthermore, each student will analyze a recent research paper in one of the two fields in self-study and present it to the course to train the ability to understand advanced concepts. Beyond that, for further training of these skills, the paper presentations will be discussed in the course.

Media:
Slide presentation, blackboard, discussion forums in e-learning platforms

Reading List:
Pattern Recognition and Machine Learning, Christopher M. Bishop
Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville

Responsible for Module:
Prof. Dr. Dominik Grimm, Florian Haselbeck

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

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

Module Description

CS0261: Phytopharmaceuticals and Natural Products | Phytopharmaceuticals and Natural Products [Phytopharm]

Version of module description: Gültig ab summerterm 2022

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

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

Description of Examination Method:
Knowledge of the covered topics of phytopharmaceuticals and natural products compounds is assessed in a written examination (90 minutes). In addition, students are required to explain the medicinal effects of medicinal plants in the examination using examples.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Organic and anorganic chemistry, botany

Content:
Content of the lecture:
-definition of medicinal plants and phytopharmaceuticals
-position of phytopharmaceuticals in pharmacology
-compounding (tea drugs, soluble extracts, sCO2 extracts, steam destillation, pure substances)
-effect-determining components and frequent mechanisms (inflammation cascade, infections, coagulation system, neurotransmission, digestive system)
-typical medicinal plants grown in Europe
-international trade in medicinal plants
-important classes of compounds (terpenes, steroids, coumarine, alcaloids, vitamins, saccharides)
-quality determination and typical methods (chromatography)
-falsification and chemotype (chemical race)
-drug regulator affairs (authorisation, documents)
-use of medicinal plants in practice

Intended Learning Outcomes:
After their participation, students can explain the production of phytopharmaceuticals derived from typical medicinal plants (from collection to quality control). They can relate chemical compounds and medical effects of typical examples.

Teaching and Learning Methods:
The lecture takes the form of oral presentation given by teaching staff with the help of PowerPoint media, books and other written material.

Media:
PowerPoint presentation and printed handout. Laboratory equipment for experiments.

Reading List:
Deutschmann, F., Hohmann, B., Sprecher, E., Stahl, E., Pharmazeutische Biologie, 3 Bde., G. Fischer Verlag, 1992

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

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

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

Module Description

CS0265: Biorefinery | Biorefinery [BioRaff]

Version of module description: Gültig ab winterterm 2023/24

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

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

Description of Examination Method:
Students answer questions in a written examination (60 minutes) that will be graded. They thereby show that they have understood, can explain and are able to assess the various steps and processes involved in biorefinery. In an additional voluntary coursework (Mid-term), which is not part of the written exam, students individually study selected topics in the field. Here, they apply their knowledge acquired in lectures to deduce and/or evaluate processing methods. Findings are presented in a "research paper" and a short presentation (5 min). Bonus points (up 10/60 depending on the quality) will be awarded for the coursework on the written exam.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in chemistry and biology; Module "Renewables Utilization"

Content:
Contents of the module include:
comparison of biorefinery and mineral oil refinery; role of biorefineries for the development of a sustainable biobased economy; presentation and analysis of different biorefinery systems (e.g. green biorefinery, lignocellulose biorefinery);
selected procedures for the extraction of resources (focused on lignocellulose);
selected biogenic compounds for further processing (e.g. saccharides, lipids/oils, lignin);
selected pathways of their use (e.g. bioalcohols, polylactic acid, proteins, succinate and other components);
cascade use of materials and energy.

Intended Learning Outcomes:
After completion of the course, students will have understood the concept of biorefinery, analogous to and in contrast with mineral oil refinery. Students are able to describe various biorefinery concepts and methods for processing renewable resources in biorefineries. The understand the importance of biorefineries for a future sustainable biobased economy. They are able to apply their knowledge to the analysis and assessment of viable biorefinery systems, taking into account their respective advantages and disadvantages. In addition, they have trained their competences in literature research and critical evaluation as well as in the preparation of "research papers".

Teaching and Learning Methods:
Lecture: talks given by teaching staff; Exercise: more detailed studies on selected topics; students individually prepare one topic and finally present their results ("research paper").

Media:
PowerPoint presentation, blackboard

Reading List:
B. Kamm, P. R. Gruber, M. Kamm (Hrsg.), Biorefineries - Industrial Processes and Products, Vol. 1-2, Wiley-VCH, Weinheim, Germany, 2006

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

Courses (Type of course, Weekly hours per semester), Instructor:
Biorefinery (Lecture) (Vorlesung, 2 SWS)
Schieder D

Biorefinery (Seminar) (Seminar, 1 SWS)
Schieder D
For further information in this module, please click campus.tum.de or here.

Module Description

CS0266: Sustainable Chemistry | Sustainable Chemistry

Version of module description: Gültig ab summerterm 2024

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

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

Description of Examination Method:
The examination will take the form of a written test (60 minutes). In this examination the competence for the evaluation of chemical processes and for the derivation of optimization strategies shall be proven. No aids are permitted in the written examination. In order to additionally check whether the students are able to communicate scientific topics in front of an audience and whether they are able to critically deal with problems in individual steps, the results of the processing of the case studies are presented in the form of a 20-minute presentation alone or in a group. This presentation is ungraded study achievement.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful participation in the module "Basics in chemistry" or comparable knowledge in chemistry.

Content:
The module teaches basic principles of sustainable chemistry. Focus is set on the evaluation of chemical processes in view of efficiency, atom economy and amount of waste. In addition, optimizsation strategies related to catalytical methods, raw material and energy efficiency are discussed. Students individually prepare current topics related to sustainable chemistry and present them in the seminar.

Intended Learning Outcomes:
By attending the module events, students are able to highlight the principles of sustainable chemistry. Students can analyze the efficiency and waste quantities of chemical reactions and evaluate various alternative processes. Furthermore, they are able to discuss further chemical aspects of the conversion of renewable raw materials into valuable products. Through the

independent development of case studies, the students master all the steps that are important in the critical examination of problems (consideration of the example, development of criteria for evaluation, assessment, presentation of the results to an audience).

Teaching and Learning Methods:
Lecture with board addresses and presentations: Basic development and derivation of technical contents; seminar with written tasks. Consolidation of the technical learning contents through learning activity of the students themselves, e.g. through independent development of case studies from the field of sustainable chemistry.

Media:
Presentation, script, examples

Reading List:
Stanley E. Manahan: Green Chemistry, ISBN: 0-9749522-4-9

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

Courses (Type of course, Weekly hours per semester), Instructor:
Sustainable Chemistry (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J, Zollfrank C
For further information in this module, please click campus.tum.de or here.

Module Description

CS0267: Biological Materials | Biological Materials

Version of module description: Gültig ab winterterm 2023/24

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

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

Description of Examination Method:
Understanding of the course contents and their application will be tested in a written exam of 90 minutes duration. In detail, the students are required to describe the physical and chemical foundations of the formation, as well as relations between the hierarchical structure and properties, of typical biological materials. Further, the transfer of this knowledge to technological applications and to the design of novel biologically inspired materials, as covered in the course, is a test subject. Lecture notes are not permitted.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in geometry and chemistry

Content:
The module Biological Materials in Nature and Technology covers important biological functional materials, based on basic materials scientific knowledge. This encompasses such materials that fulfill, in their biological system, or in a technological application, either in native state, or modified, one or more specific functions. Differences and similarities to classical engineering materials are pointed out. In addition to the modules Bioinspired Materials and Instrumental Analysis, the students learn important methods for structural and property analysis. After a presentation of the classification of biological materials, students- are taught the basic correlations between hierarchical structuring and macroscopic properties. As the most important complex, the influence of hierarchical structuring on the mechanical properties of materials will be discussed. The students learn, which modes of failure can occur in biological systems and how they are influenced. In this context, modification routes for biological materials are shown and discussed.

Intended Learning Outcomes:
After successful completion of the module, the students are enabled to name criteria for a proper usage of biological materials. They can name specialized methods for the analysis of hierarchical structures and the derived material properties and explain the correlations between structure and external properties. Further, they are able to describe tailored modification routes for biological materials.

Teaching and Learning Methods:
Lecture with discussion and case studies

Media:
Presentation, slides

Reading List:
Structural Biological Materials: Design and Structure-Property Relationships. Eds Elices M, Pergamon-Elsevier Science Ltd, Oxford, (2000).
Fratzl P & Harrington MJ. Introduction to Biological Materials Science. Wiley VCH, Weinheim, Germany, (2015).

Responsible for Module:
Van Opdenbosch, Daniel; 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

CS0268: Applied Process Engineering | Applied Process Engineering [APE]

Applied process engineering

Version of module description: Gültig ab summerterm 2023

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:
The examination is performed in the form of a written examination (60 minutes). The students prove that they can solve arithmetic problems and apply methods of cost estimation and economic feasibility studies of process engineering processes as well as answer questions about optimization and cost reduction in writing.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Apparatus and plant construction, bioprocess engineering, chemical reaction technology, thermal process engineering

Content:
The module teaches the basics that are necessary for estimating costs and assessing the profitability and sustainability of a production process. Various methods of cost estimation are taught, as well as their suitability and accuracy in different project phases. The contents are in particular the following:

- Project/design phases (proof of principle, process development in the laboratory, piloting, demonstration, concept study, basic engineering, detail engineering, construction, commissioning, production, debottlenecking)
- Cost estimation (methods, including the Monte Carlo method, accuracy, process variants, sensitivity analyses, tornado plots)
- Assessment of Sustainability

- Investment versus CMO production
- Site selection and plant size
- permits
- Time plans
- Selected examples from industry
- (Operational) optimization and Lean Six Sigma tools
- Business Case Evaluation (Payback, Discounted Cash Flow, Net Present Value, Sales at Maturity)

Intended Learning Outcomes:
After participating in the module, the students are able to estimate operating and investment costs in the respective design phases for a production plant and to reduce production costs during the operation of a plant.

Teaching and Learning Methods:
In the lecture, the essential basics are presented and worked out. The content learned is applied to concrete practical questions in the exercise. Special software for cost estimation is learned in a computer exercise and sample calculations are carried out. Individual topics are worked on and presented in groups. After participating in the module, the students are able to apply the basics of cost estimation and to evaluate the profitability and sustainability in different project phases.

Media:
Presentations, interactive quizzes, case descriptions, computer exercises with software

Reading List:
Peters, M. S., Timmerhaus, K. D., West, R. E., 2003. Plant Design and Economics for Chemical Engineers. McGraw-Hill Education. ISBN 9780072392661

Vasudevan, P. T., Ulrich, G. D., 2004. Chemical Engineering Process Design and Economics: A Practical Guide. United States: Process Pub.. ISBN 9780970876829

Penney, W. R., Couper, J. R., Fair, PhD, J. R., 2012. Chemical Process Equipment: Selection and Design. Netherlands: Elsevier Science. ISBN 9780123969590

Towler, G., Sinnott R., 2021. Chemical Engineering Design - Principles, Practice and Economics of Plant and Process Design. Elsevier. ISBN 9780128211793

Chmiel, H. Bioprozesstechnik. (2011). Germany: Spektrum Akademischer Verlag. ISBN 9783827424761

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

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

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

Module Description

CS0273: Electrochemical Modelling | Electrochemical Modelling [ECM]

Version of module description: Gültig ab winterterm 2023/24

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

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

Description of Examination Method:
The learning results are demonstrated in form of a project. The students pick a topic of their interest in electrochemical modelling from a prepared selection. The students present this topic to their peers in the form of an 20 minute long oral presentation (+10 min discussion). In explaining their chosen topic, the students should utilize one or more of the methods learned in this course. After four weeks the student’s work is present and evaluated. The student is graded based on his/her progress and approach presented in the oral summary.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
The student should know general chemistry, physics, and mathematics. Furthermore, a good knowledge of physical chemistry and electrochemistry is necessary. A basic knowledge of computer programming i.e., MATLAB is preferable.

Content:
- Physical models: continuum approximation, conservation laws, constitutive relationships, boundary conditions and the current distribution, microscopic models of electrode kinetics.
- Formulation and approximation: scaling and dimensional analysis, dimensionless groups.
- Steady-state systems: modelling voltammetry under steady reaction-diffusion, methods for solving linear systems, approximate/asymptotic methods for non-linear reaction kinetics.
- Transient systems: modelling transient potential step chronoamperometry and cyclic voltammetry with and without reactions.
- Numerical methods: approximations for first and second derivatives, explicit and implicit methods.

Intended Learning Outcomes:
The students understand the basic concepts of modelling electrochemical systems, focusing on a breadth of analytical and numerical methods applicable to solving a wide range of different systems. Furthermore, they are able to identify key processes and boundary conditions and translate these into mathematical expressions. Thus, they can systematically implement simplifications to model complex electrochemical phenomena. Importantly, they can formulate a problem and find an approximate solution using scaling, dimensionless groups, and dimensionality reduction. In particular, they can analyse and distinguish between various electrochemical methods and know how to model these. Overall, they succeed in planning and constructing their own mathematical models, which they can solve either analytically or numerically to find the current response, while reviewing and evaluating their assumptions for deriving the governing mathematical equations.

Teaching and Learning Methods:
The teaching content is presented with lectures, text documents, PowerPoint presentations, and blackboard sketches. This enables a way of delivering the teaching content to the students in detail and answering questions as soon as they arise. PowerPoint slides and blackboard sketches add visual assistance to understand the complex relationships in electrochemistry and how to express these relationships in terms of mathematical equations. Additionally, the students are provided with exercises to consolidate what they have learned in the lecture with hands-on modelling examples and reviewing the mathematical tools necessary to solve the equations. The exercises and solution are discussed and explained in the practical lessons.

Media:
Presentations, PDF-script, case studies and algorithms for models in MATLAB.

Reading List:
R. G Compton, E.Laborda, K. R. Ward, Understanding Voltammetry: Simulation of Electrode Processes.
J. M. Savéant, C. Costentin, Elements of Molecular and Biomolecular Electrochemistry.
A. J. Bard, L. R. Faulkner Electrochemical Methods: Fundamentals and ApplicationsElectrochemical Methods: Fundamentals and Applications.

Responsible for Module:
Plumeré, Nicolas; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Electrochemical Modelling (Vorlesung, 2 SWS)
Johnson III B [L], Höfer T, Johnson III B

Electrochemical Modelling (Übung, 2 SWS)
Johnson III B [L], Johnson III B
For further information in this module, please click campus.tum.de or here.

Module Description

CS0305: Research Excursion Master | Research Excursion Master

Version of module description: Gültig ab summerterm 2024

Module Level: Master	**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 students deliver a learning portfolio consisting of the following elements::
1. 2 written pages or 20' presentation on 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. 5-10 PPT slides reflecting the findings based on a case study visited during the excursion. The due date will be specified in the kick-off session;
4. Final report of case studies and results of the workshop;

All four 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 topics from modules and / or the study programs for which it is designed. On an individual basis, professors and lecturerers from these modules / study programs 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.

After the excursion the results of the applied methodologies are presented and discussed in a workshop. Key findings and the results of the workshop are included in a final excursion report by the students.

Intended Learning Outcomes:
The excursion aims to support the scientific profile building of students and the acquisition of scientific, practical and social competencies and the application to case studies visited during the excursion. 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 apply their competencies to real case studies in practice.

In particular, the intended learning outcomes are the following:
- Select relevant scientific and practical information and recall it for for visits of 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,
- Perform structured interviews and talks with experts and stakeholders in practice
- Apply methodologies from theoretical lectures and exercises on practical organizations

Teaching and Learning Methods:
The research excursion consists typically of the following elements (teaching, learning and application of methods):
- Kick-off session: To achieve a good get-to-know, brief the students about the module contents, course and required performance an interactive in-presence workshop will be carried out. This covers presentations, and interactive elements such as role games 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, interviews of experts 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,
- Workshop: the students will present and discuss their findings in a workshop to gain practical experience for their future working conditions and formulate a final excursion report.

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

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

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

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

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

Module Description

WZ1120: Medicinal and Spice Plants | Heil- und Gewürzpflanzen

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

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

Description of Examination Method:
In a written examination (60 minutes), students demonstrate their ability to identify important medicinal and aromatic plants, as well as outline methods of cultivation, harvesting and drying. In addition, they have a limited time frame to classify medical effects and chemical compounds. During the course of the module, students give a detailed presentation on certain medicinal and aromatic plants, which also informs the assessment.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Organic and anorganic chemistry, botany, plant cultivation or Introduction to biology (WZ1110), chemistry (WZ1106), cultivation systems (WZ1107).

Content:
History of medicinal plants, identification of medicinal plants, special aspects of cultivation of aromatic plants, plant protection and harvesting. Drying methods used for herbs. Different classes of active substances, such as terpenes, coumarin, flavonoids and certain effect-determining ingredients. Several extraction and analysis methods of isolation of the active substance, e.g. Soxhlet extraction, thin-layer chromatography or infrared spectroscopy. Frequent mechanisms of action, e.g. inflammation cascade, infections, neurotransmission or digestion system. Current cultivation systems and use of medicinal and aromatic plants.

Intended Learning Outcomes:
After participation in the module, students know how to characterize medicinal and aromatic plants, inclucing basics of cultivation systems in herb gardens and fields. They are aware of different techniques such as drying and harvesting of various medicinal and aromatic plants. Examples are used to demonstrate the students' ability to classify medical effects and chemical compounds.

Participating in tutorials on laboratorial work, students learn how to perform analytical-chemical analyses on medicinal and aromatic plants as well as deducing the respective classes of active substance.

Teaching and Learning Methods:
Lecture (talks given by teaching staff using PowerPoint media, books and other written material), excursion to process engineering company. Tutorials (e.g. students perform supervised experiments)

Media:
PowerPoint presentation and lecture notes.
Laboratory equipment for experiments, exercises about analysis

Reading List:
Deutschmann, F., Hohmann, B., Sprecher, E., Stahl, E., Pharmazeutische Biologie, 3 Bde., G. Fischer Verlag, 1992
Wendelberger, E., Heilpflanzen: Erkennen | Sammeln | Anwenden Broschiert – BLV Buchverlag Januar 2013
Dingermann, Hiller, Schneider, Zündorf 2011, Arzneidrogen Spektrum akademischer Verlag

Responsible for Module:
Alexander Höldrich (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.

Module Description

WZ1193: Biogas Technology | Biogastechnologie [BiGA]

Version of module description: Gültig ab summerterm 2024

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	100	50

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

Description of Examination Method:
Students take a written examination (90 minutes) to demonstrate their knowledge of microbial breakdown processes in the biogas process, as well as their ability to assess influencing factors. They also demonstrate their knowledge of various technologies for using biogas and can explain their respective advantages and disadvantages. Additionally, they demonstrate that they have understood the legal and economic framework conditions of biogas technology and are able to translate these to case examples. Students also show that they can develop basic concepts of biogas plants.They will answer questions on the topic in their own wording and explain case examples or work out calculations. Multiple-choice questions are also possible.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Required: basic knowledge in biology, especially microbiology, as well as general and organic chemistry, mathematics, physics and thermodynamics of cycles; of advantage: knowledge in agriculture and agricultural engineering

Content:
Microbiology of biogas processing, anaerobic substrate breakdown, factors influencing the fermentation process, process management strategies, biogas storage and purification; biogas recovery (e.g. use of a motor for power generation with or without the use of heat or feeding into the gas grid); legal-economic framework conditions; sustainability issues; competition for raw material and acceptance of biogas plants; aspects of biogas plant design.

Intended Learning Outcomes:
After successful completion of the module, students are able to develop concepts for biogas generation and recovery in a specific context. Students are aware of microbial breakdown

processes in biogas plants and can differentiate between various influencing factors. They are also aware of various processes for the use of biogas and understand their advantages and disadvantages. Students recognize the meaning of biogas technology for sustainable energy supply. Students have a good knowledge of legal and economic framework conditions in the field of biogas generation and they are able to conceptualize basic biogas plants.

Teaching and Learning Methods:
Lectures given as presentations, with the help of a blackboard and interactive elements, in particular group work on case examples; optional: excursion to a biogas plant to deepen acquired knowledge in a real-life setting

Media:
PowerPoint presentation, slide notes, exercise sheets

Reading List:
D. Deublein, A. Steinhauser, Biogas from Waste and Renewable Resources - An Introduction, Wiley-VCH, 2010, ISBN-13: 978-3-527-32798-0, ISBN-10: 3-527-32798-3

Responsible for Module:
Doris Schieder (doris.schieder@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

WZ1664: Energy Storage | Energy Storage

Version of module description: Gültig ab winterterm 2021/22

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

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

Description of Examination Method:
The examination is a 90-minute written final exam. Students prove in exercices their ability to perform the laying-up of energy storage systems and to calculate their specifications and properties. Furthermore the general understanding of different storage technologies and their specific characteristics is tested. The only aid allowed is a handheld calculator.
A term paper is a requirement for the final exam but is not part of the final grade.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Technical Thermodynamic, basic but profound knowledge in physics

Content:
The course energy storage gives an overview of established storage systems as well as those being under way. The setup and operation mode of different kinds of energy storage (thermal, mechanical, chemical, electrical and eletrochemical) as well as their application and integration is presented. The status quo of technology and the potential for improvement is depicted.

Intended Learning Outcomes:
The course enables the students to fully understand the complex structures involved in energy storage. They know about different storage types and concepts for heat and electricity. Characterisation on the basis of technical and economic figures is possible.

Teaching and Learning Methods:
The module consists of a lecture course with integrated practical elements. The lecture's content are mediated by the instructor's presentation and exercise examples. By solving given tasks at

home and if necessary students presentations the acquired knowledge is consodiated. The writing of the term paper is also a means of consolidation.

Media:
Powerpoint, whiteboard, exercise sheets

Reading List:
Sterner, M.; Stadler, I.: Energiespeicher, Springer Vieweg, ISBN 978-3-642-37379-4, 2014
Rummich, E.: Energiespeicher, expert-Verlag,
ISBN: 978-3-8169-3297-0, 2015
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.

Biogenic Polymers | Biogenic Polymers

Module Description

CS0104: Biogenic Polymers | Biogenic Polymers [Bioplar]

Version of module description: Gültig ab winterterm 2020/21

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

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

Description of Examination Method:
During the seminar, students independently work on a topic from the field of biogenic polymers, and give an oral presentation. Group work is optional. Assessment requires an oral examination (30 minutes). Students demonstrate their knowledge of physico-chemical properties of biogenic polymers as well as possible applications. Students are able to develop options for chemical synthesis and analysis of physico-chemical properties of bioplastics. No further tools are allowed in the examination.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful participation in "Basics in Chemistry" and knowledge of materials and chemical compounds, or comparable knowledge on chemistry and physics.

Content:
The module deals with structure and function of natural bio-macromolecules (in particular polysaccharids and proteins). Furthermore, basics of biogenic polymers will bei discussed in the view of polymers holding potential for applications in future technology. The topic of chemical synthesis and derivatization of bioplastics for use in industry is introduced (e.g. cellulose derivatives). Special focus is set on the development of options for chemical synthesis and its competent application. Physico-chemical properties of bioplastics as well as their characterization is central to the lecture.
The seminar takes the form of a journal club with students independently work on reserach papers and their presentation to fellow students.

Intended Learning Outcomes:
After participation, students are able to classify different kinds of bioplastics with respect to their possible application. They are competent to evaluate the production processes of biopolymers used in technology and can classify them according to their profile of properties. The module enables students to decide on appropriate synthesis methods to meet specific requirements in the industry. Students will also be able to use physico-chemical analysis methods in a competent way.

Teaching and Learning Methods:
Lecture (talks given by teaching staff using PowerPoint media, books and additional written document), seminar (independent work on a topic including a presentation, peer instruction and constructive criticism)

Media:
Presentations, slide notes

Reading List:
Endres, H.J., Seibert-Raths, A., Technische Biopolymere, Carl Hanser Verlag, München, 2009

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

Courses (Type of course, Weekly hours per semester), Instructor:
Biogenic Polymers (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J

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

Energy and Economics | Energy and Economics

Module Description

CS0260: Energy and Economics | Energy and Economics [EUW]

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**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 will take the form of a written test (60 minutes). The students prove that they can understand and answer questions and the connections between the energy conversion, the conversion of renewable raw materials, the energy supply in general and the current energy-political and economic situation. Group work can be included and be part of the exam.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Prior participation and passing of the fundamentals of Thermodynamics module is required for participation in the Energy and Economics module.

Content:
The module deals with the basics of energy sources, climate change and the technology of the heat, electricity and fuel market and the use of renewable raw materials, including an introduction to simple technical systems and current topics on the energy industry. It also deals with electricity trading, CO2 trading and the current situation of various energy technologies.
In exercises small examples are calculated to the economy (production costs of heat and power of plants (e.g. combined heat and power plants).

Intended Learning Outcomes:
By participating in the module, students will be able to understand the energy sources and simple principles of energy conversion into heat and electricity. They can perform simple economic assessments of energy systems and understand related market mechanisms of the electricity and heat market.

Teaching and Learning Methods:
The module consists of a lecture with exercises. The contents of the lecture are conveyed in the lecture and through presentations.

Media:
Presentations, exercise

Reading List:
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:
Gaderer, Matthias; Prof. Dr.-Ing.

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

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

Module Description

WZ1180: Introduction Energy Conversion and Energy Economics | Einführung Energiewandlung und Energiewirtschaft

Version of module description: Gültig ab winterterm 2017/18

Module Level: Master	**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:
Assessment takes the form of a written examination (60 minutes). Students demonstrate their understanding of connections relevant to energy conversion, the use of renewable resources as a source of energy, energy supply in general, and the current political and economic situation.

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
The module deals with the basics of the heat, electricity and fuel market and the use of renewable raw materials, including an introduction to simple technical systems and current topics relating to the energy industry. For example, electricity trading, CO_2 trading and the situation of generation plants are dealt with.
In exercises, small examples of the economic efficiency (production costs) of plants are calculated (e.g. combined heat and power generation).

Intended Learning Outcomes:
After participation students understand the basics of energy conversion with regard to heat, electricity and fuel. They can explain the role of market forces in in the electricity and CO_2 trade as well.

Teaching and Learning Methods:
The module comprises lectures and tutorials (including an excursion). The contents are presented in talks and presentations. 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, practical course

Reading List:
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 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.

Geothermal Energy Systems | Geothermal Energy Systems

Module Description

CS0263: Geothermal Energy Systems | Geothermal Energy Systems [GeoE]

Potentials of geothermal energy supply

Version of module description: Gültig ab winterterm 2022/23

Module Level: Master	**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 geothermal systems and their potential for energy supply in form of a written examination (90 minutes). Students deliver definitions, describe and outline relevant processes for the geothermal energy supply. Furthermore, students calculate different technical specifications and parameters based on provided practice-oriented examples.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful completion of the module "Basics in engineering" and "Introduction to Energy conversion and Energy economy". Knowledge and interest in Geology and Physics are valuable.

Content:
The course focuses on the variety of options for geothermal energy supply. This includes an introduction to relevant geological expert knowledge such as formation of the earth, earth's structure, geothermal heat sources, the rock-cycle as well as mechanism of subsurface heat transport. After an introduction to deep geothermal exploration (drilling, drilling technology and related risks) the focus of the course is placed on shallow geothermal energy and use of ground-coupled heat pump systems.

This includes the design and working principle of a heat pump system and its integration in technical building equipment as well as the analysis of their ecological and economic sustainable operation on living quarter scale. The analysis is also done with regards to existing technical guidelines as well as legal boundary conditions. Practice-oriented tasks will be used to demonstrate and critically evaluate the basic planning steps of heat pump systems and obtaining the relevant parameters. Existing and innovative geothermal exploration concepts will be analyzed and discussed against this background.

Intended Learning Outcomes:
After successful completion of the module, students acquire in-depth understanding of geothermal energy systems including relevant geological and hydrogeological processes. Students can evaluate the ecological as well as economic sustainability of geothermal heat source systems. They can test plausibility of dimensioning ground-coupled heat pump systems and understand, explain and comprehend heat transport processes and regeneration processes within the subsurface.

Students prepare short, practice-oriented tasks as homework 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 passed on to the other participants accordingly with the focus on sharing results in the form of a written report as well as team work.

Teaching and Learning Methods:
The content is taught in lectures and presentations and strengthened by case studies and exercises. If applicable, the module is complemented by an excursion.

Media:
Lecture, Power Point presentation, blackboard, case examples, topics prepared and presented by participants.

Reading List:
Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen (2005): Oberflächennahe Geothermie.
Bauer, M., Freeden, W., Jacobi, H., Neu, Th. (Hrsg.) (2018): Handbuch Oberflächennahe Geothermie. Springer Spektrum, 1. Auflage.
Stober, I. & Bucher, K. (2014): Geothermal Energy. Springer Spektrum, 1st edition.
Hölting, B., Coldewey, W.G. (2013): Hydrogeologie. Springer Spektrum, 8. überarbeitete Auflage.
Dassargues, A. (2018): Hydrogeology: Groundwater Science and Engineering, CRC Press, 1st edition.
Grotzinger, T. & Jordan, T. (2017): Press/Siever Allgemeine Geologie. Springer Spektrum, 7. Auflage
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:
Geothermal Energy Systems (Vorlesung mit integrierten Übungen, 4 SWS)
Vienken T [L], Vienken T
For further information in this module, please click campus.tum.de or here.

Polymer Processing | Polymer Processing

Module Description

CS0264: Polymer Processing | Polymer Processing [PolyProc]

Processing of polymers intro plastic parts

Version of module description: Gültig ab summerterm 2024

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

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

Description of Examination Method:
The content and learning objectives of the lecture are examined at the end of the semester in a written test (90 min). An oral pre-test containing safety relevant laboratory work issues must be carried out before the individual pratical course. A written report on the practical course consisting of approximately five pages must be submitted. The written report is an ungraded student achievement.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Polymer chemistry, polymer physics, rheology fluid mechanics, Biogenic Polymers

Content:
The lecture deals with unit operations, basic techniques and processes of plastic material processing, e.g. compounding, extrusion, injection molding, plastic part forming processes and also typical applications. In addition, methods for characterizing thermal and mechanical properties are presented. One focus here is the connection between the processing parameters and the end-use properties. The acquired knowledge is deepened in the accompanying practical course. Injection molding and extrusion tests are carried out and the test specimens are then characterized with regard to their thermal, optical and mechanical properties. Additional foci will be laid on the chemistry, structure and classification of polymers and plastic parts. The lecture also deals with the physical properties of polymers and plastic materials involving materials science. Characterization of the mechanical and thermal properties and their effects on processing, viscosity, viscoelastic behavio will be discussed

Intended Learning Outcomes:
In addition to the chemical-physical basics of polymeric materials, this module imparts the methodical knowledge about classic and modern innovative processing methods of polymeric materials. The students are able to sensibly classify plastic materials, their manufacture and use them for specific applications. The basics for the production technology of plastic materials are acquired. After successfully completing the module, students are able to select and use methods for processing plastic. They will be able to assess sustainability aspects of the polymer production process in terms energy consumption and materials use. Through practical work, the competence for the meaningful use of testing and characterization methods of polymer materials is acquired.

Teaching and Learning Methods:
Lecture (lecture by teaching staff with Power Point slide media, books and other written material), laboratory practical course (experimentation of the students under supervision)

Media:
Power Point slide presentations; Drawing and writing on a black board; Laboratory equipment for experimentation

Reading List:
Polymer Engineering; Technologien und Praxis; Peter Eyerer, Peter Elsner, Thomas Hirth
Polymer Extrusion; Chris Rauwendaal
Extrusion: The Definitive Processing Guide and Handbook; Harold F. Giles, Jr.
Einführung in die Kunsstoffverarbeitung; Michaeli, W.
Werkstoffkunde der Kunststoffe; Menges, G.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Polymer Processing (Practical) (Praktikum, 1 SWS)
Zollfrank C [L], Helberg J

Polymer Processing (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Helberg J
For further information in this module, please click campus.tum.de or here.

Research Internship (max. 10 ECTS) | Research Internship (max. 10 ECTS)

Module Description

CS0294: Research Internship Master 5 ECTS | Research Internship Master 5 ECTS

Version of module description: Gültig ab summerterm 2024

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

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

Description of Examination Method:
The examination consists of a graded internship report (15-30 pages, depending on the topic) on the contents and contents of the internship results containing at least an overview of the state of knowledge on the project topic as well as the presentation of the working methods used and a presentation of the results with interpretation. In an overall grade, the quality of the familiarisation with the topic, the experimental work, the interpretation of the results and the written elaboration are evaluated.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Background knowledge of the respective focus to which the project topics of the research internships are assigned. In this case, having a background in Python or SuperPro Designer and experience in the laboratory is often recommended.

Content:
Research-related work at the chairs and working groups of the TUM Campus Straubing. The students receive tasks from the research area of the supervising examiner, which they work on under guidance in the form of projects. The subject areas must be able to be assigned to the technical content of the study program. The students plan the project work largely independently under the guidance of the supervisors. The project work consists of 120 working hours, fixed in consultation with the supervisors, usually as a block internship on consecutive weeks, which can be deviated from in consultation. The project work is documented and evaluated in the form of an

internship report. In addition, a supplementary presentation of the work progress takes place. The project work can also be done with external institutions, such as companies.

Intended Learning Outcomes:
After participation in the module, students understand the principles of approach to (research)projects in addition to the subject-specific knowledge and working methods taught in the research internship projects, the planning of project work and the critical evaluation of the project results and can apply them to new project tasks. Furthermore, they are able to document, interpret and summarise project work and results in written form.

Teaching and Learning Methods:
Depending on the focus and topic, for example, experiments in laboratories, guided or independent literature and data research, concept studies, simulations, methods for project and experimental design or test evaluation

Media:
Depending on the focus and topic, e.g., experimental equipment (laboratory), databases, libraries, specialized software, programming software, simulation software, project and experimental design software

Reading List:
technical literature;
Davies, M. B. (2007): Doing a successful research project. Using qualitative or quantitative methods. Basingstoke: Palgrave

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

Courses (Type of course, Weekly hours per semester), Instructor:
Research Internship Master 5 ECTS (Praktikum, 5 SWS)
Blombach B, Glawischnig E, Hädrich M, Vital S

Research Internship Master 5 ECTS (Forschungspraktikum, 5 SWS)
Costa Riquelme R [L], Costa Riquelme R

Research Internship Master 5 ECTS (Forschungspraktikum, 5 SWS)
Sieber V [L], Abbas Nia A, Al-Shameri A, Arana Pena S, Dsouza Z, Fornoni E, Friedrichs J, Fuchs A, Giustino A, Grundheber J, Hofer N, Hörnschemeyer K, Hupfeld E, Kampl L, Köllen T, Liu Y, Malubhoy Z, Marosevic M, Matena F, Mayer M, Ostertag T, Raga Carbajal E, Rau M, Romeis D, Rühmann B, Scheerer J, Schieder D, Schulz M, Sieber V, Siebert D, Skopp A

Research Internship Master 5 ECTS (Forschungspraktikum, 5 SWS)
Zavrel M [L], Beerhalter D, Borger J, Dsouza V, Geisler N, Marino Jara J, Oktay I, Stegemeyer U, van der Walt H, Zavrel M

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

Module Description

CS0297: Research Internship Master 10 ECTS | Research Internship Master 10 ECTS

Version of module description: Gültig ab summerterm 2024

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

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

Description of Examination Method:
The examination consists of a graded internship report (15-30 pages, depending on the topic) on the contents and contents of the internship results containing at least an overview of the state of knowledge on the project topic as well as the presentation of the working methods used and a presentation of the results with interpretation. In an overall grade, the quality of the familiarisation with the topic, the experimental work, the interpretation of the results and the written elaboration are evaluated.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Background knowledge of the respective focus to which the project topics of the research internships are assigned. In this case, having a background in Python or SuperPro Designer and experience in the laboratory is often recommended.

Content:
Research-related work at the chairs and working groups of the TUM Campus Straubing. The students receive tasks from the research area of the supervising examiner, which they work on under guidance in the form of projects. The subject areas must be able to be assigned to the technical content of the study program. The students plan the project work largely independently under the guidance of the supervisors. The project work consists of 360 working hours, fixed in consultation with the supervisors, usually as a block internship on consecutive weeks, which can be deviated from in consultation. The project work is documented and evaluated in the form of an internship report. In addition, a supplementary presentation of the work progress takes place. The project work can also be done with external institutions, such as companies.

Intended Learning Outcomes:
After participation in the module, students understand the principles of approach to (research)projects in addition to the subject-specific knowledge and working methods taught in the research internship projects, the planning of project work and the critical evaluation of the project results and can apply them to new project tasks. Furthermore, they are able to document, interpret and summarise project work and results in written form.

Teaching and Learning Methods:
Depending on the focus and topic, for example, experiments in laboratories, guided or independent literature and data research, concept studies, simulations, methods for project and experimental design or test evaluation

Media:
Depending on the focus and topic, e.g., experimental equipment (laboratory), databases, libraries, specialized software, programming software, simulation software, project and experimental design software

Reading List:
technical literature;
Davies, M. B. (2007): Doing a successful research project. Using qualitative or quantitative methods. Basingstoke: Palgrave

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

Courses (Type of course, Weekly hours per semester), Instructor:
Research Internship Master 10 ECTS (Forschungspraktikum, 10 SWS)
Banlaki I, Crean E, Gaizauskaite A, Kalkowski J, Li Y, Niederholtmeyer H

Research Internship Master 10 ECTS (RES) (Praktikum, 10 SWS)
Gaderer M [L], Huber B, Putra L

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

Interdisciplinary Electives | Fachübergreifende Wahlmodule

Module Description

CS0111: Advanced Development Economics | Advanced Development Economics

Version of module description: Gültig ab winterterm 2023/24

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

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

Description of Examination Method:
The examination will be given in the form of a written examination. The students should be able to evaluate and justify general and detailed theories, methods and concepts of the environmental and resource economy. Important international examples will be explained. Type of examination: written, no additional tools allowed, duration of examination: 60 minutes

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Micro- and Macroeconomics

Content:
Why are some countries developing and some are trapped in poverty? What are the determinants of economic growth? What is the role of demography, institutions (in particular the state), the environment, labor, migration, capital or credit markets in the development of states? What is the importance of development aid & cooperation? These are some of the questions that decision-makers in the developed and developing countries have to discuss every day. This course provides a theoretical foundation and empirical evidence for the analysis of the most important questions of today's development of the world.

Intended Learning Outcomes:
After visiting the module, the students can use the development economy to understand what is hindering development and what factors lead to success. They can apply theories, concepts, and analytical techniques associated with macroeconomics. Students learn to understand the

difference between growth and development, the reasons and impact of migration, the role of institutions (e.g. properte and use rights), development cooperation and international trade. The students are able to analyze empirical evidence on economic development and to critically read the literature in the field of economic development.

Teaching and Learning Methods:
The lecture and the exercise will be done by PowerPoint. In addition, current examples from newspapers and journals will be integrated into the lectures. In the exercise, the students research current case studies linked to the theories and concepts presented in the lecture. These case studies are then individually and / or groupwise discussed and questioned from different perspectives together with the students. Web lectures by internationally renowned experts and researchers will be integrated into the lecture.

Media:
Presentations, slide scripts, Articles, online lecture examples

Reading List:
Alain de Janvry, Elisabeth Sadoulet (2016). Development Economics - Theory and Practice. Routledge; Michael Todaro, Stephen Smith (2012). Economic Development, Pearson.

Responsible for Module:
Faße, Anja; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Development Economics (Lecture) (Vorlesung, 2 SWS)
Faße A [L], Faße A

Advanced Development Economics (Tutorial) (Übung, 2 SWS)
Faße A [L], Faße A, Shayo G
For further information in this module, please click campus.tum.de or here.

Module Description

WI000285: Innovative Entrepreneurs - Leadership of High-Tech Companies | Innovative Entrepreneurs - Leadership of High-Tech Companies

Version of module description: Gültig ab summerterm 2021

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

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

Description of Examination Method:
The examination performance is achieved through individual project work, which is divided into three phases. In the first phase, the students intensely engage themselves over a period of six to eight weeks with a self-chosen "Inner Development Challenge" from one of the following topic areas: Relationship to Self, Cognitive Skills, Caring for Others and the World, Social Skills, and Driving Change. Subsequently, in the reflection phase, a written reflection paper is produced in which the students critically reflect on their experiences and draw conclusions for their future.
In the Peer feedback phase, the students read and analyze five reflection papers of their fellow students. This fosters the students' ability to critically analyze their own works as well as the works of others and to give and receive effective feedback.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
- Knowledge: No special requirements, willingness to participate
- Abilities: Identifying opportunities; proactiveness; communication; commitment
- Skills: openness; analytical thinking; visual thinking; self-motivation; networking

Content:
The objective of the module is to inspire and motivate the participants coming from various disciplines for an entrepreneurial career, and to give them a basic understanding about founding and managing technology- and growth-oriented companies. To serve this purpose, the module provides an introduction to the topic of (effectual) entrepreneurship, as well as guest lectures by outstanding founders, entrepreneurs, managers, and investors on selected topics, such as:

1. The entrepreneurial ecosystem
2. Founding of companies for students and scientists
3. How to develop an idea into a market-ready product
4. Financing of startups
5. Corporate growth
6. Creating and managing an entrepreneurial culture
7. Strategic business management
8. Innovation management
9. Corporate finance
10. Business succession

Moreover, for self-motivated participants, there is ample opportunity for personal development through interactive workshops, closed networking events.

Intended Learning Outcomes:
Upon successful completion of this module, participants will be able to...
- understand the entrepreneurial mindset
- recognize and develop personal strengths
- develop and implement personal ideas
- understand Design Thinking methodology

Moreover through guest speakers' lectures and optional workshops participants will be empowered to:
- realize opportunities and challenges associated with the founding and managing of technology- and growth-oriented companies;
- create a personal roadmap for entrepreneurial success.

Thus, students familiarize with topics like opportunity recognition, innovation management, growth, leadership, and the facets of entrepreneurship. In doing that, they are enabled to see, realize, and experience the multiplicity in the everyday life of an entrepreneur, entrepreneurial personalities, as well as entrepreneurial skills and motivations.

Teaching and Learning Methods:
As guest lecturers, each week an outstanding founder, entrepreneur, manager, or investor, spanning a wide-ranging industrial spectrum, is hosted to report on their individual entrepreneurial careers.

At the end of each lecture, the participants can actively engage in discussions with the guest speaker during an open session.

Moreover, in context of a workshop, the participants venture their own personal qualities and skills to understand in a structured way their own entrepreneurial identity. In doing that, they focus on their individual strengths and resources to develop a plan to be entrepreneurial.

The module also provides participants with ample opportunity to network with people from the entrepreneurial environment of TUM.

Media:
- Lecture slides downloadable
- Online discussion forum (e.g., for questions and feedback on guest lectures)
- Handouts (distributed online)

Reading List:
Read, S., S arasvathy, S., Dew, N., Wiltbank, R., & Ohlsson, A. V. (2016). Effectual Entrepreneurship. Taylor & Francis

Responsible for Module:
Schönenberger, Helmut; Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Innovative Entrepreneurs - Leadership of High-Tech Companies (WI000285, englisch) (Vorlesung, 2 SWS)
Schönenberger H [L], Schönenberger H, Schuster C
For further information in this module, please click campus.tum.de or here.

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

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

CS0008: Enzyme Engineering | Enzyme Engineering [EE]

Version of module description: Gültig ab summerterm 2022

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

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

Description of Examination Method:
To proof whether the students are able to show ways to optimize enzymes in their properties and to perform this methodically, a written examination takes place with a duration of 60 minutes and a written seminar report must be created.The total grade consists of the written exam grade (67%) and the grade of the seminar report (33%).

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
This course aims to convey molecular biology and protein chemistry approaches to optimize enzymes especially by variation of the primary structure. Essential contents are: analysis of the limitation at the molecular level, rational methods, computer-based methods, evolutionary and combined procedures, high-throughput methods, robotics. The seminar aims to convey basic bioinformatical tools used in rational enzyme design such as ligand docking, energy minimization and rational introduction of mutations. These methods will be practiced on real enzymes and used to generate improved enzyme variants for a specific engineering target.

Intended Learning Outcomes:
After participating in the lecture the students will be able to indicate options for the improvement of technically limited enzymes, to estimate the necessary effort for these improvements and they own the theoretical ability to put these improvements into practice. After having participated in the seminar the students are able to use different bioinformatical tools for rational enzyme design and are able to evaluate the results of the generated informatical predictions.

Teaching and Learning Methods:
The lecture will be performed as ex-cathedra teaching to provide the students with all necessary fundamentals. In addition, the students review single methods and procedures by themselves e.g. based on current scientific literature and present this review to each other in a presentation. In the seminar, the students will be guided through the single steps of a rational enzyme engineering approach with the help of a script. The results of these steps will be summarized in a written report to put the single steps into a larger context.

Media:
PowerPoint, lecture script, scientific publications

Reading List:
Recommendations:
"Directed Enzyme Evolution: Screening and Selection Methods" (Methods in Molecular Biology) and "Directed Evolution Library Creation: Methods and Protocols" (Methods in Molecular Biology), both Frances H. Arnold, George Georgiou (publisher), Springer, Berlin
"Protein Engineering Protocols" (Methods in Molecular Biology), Katja M. Arndt and Kristian M. Muller (publisher), Springer, Berlin.

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

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

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

Module Description

CS0011: Conceptual Design of Bioprocesses | Conceptual Design of Bioprocesses [CDBP]

Version of module description: Gültig ab summerterm 2023

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

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

Description of Examination Method:
The exam performance is effected by an written exam (60 min). It is reviewed wheter the students know the fundamentals of chemical and bioprocess engineering and if they can apply this knowledge on the design and evaluation of complex processes.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Module "Bioprocess Engineering"

Content:
Basics of conceptual design of bioprocesses; Basics of computational process design including calculation of process parameters; transfer of fundamental scale-up criteria towards real problem solving; Balancing of all process streams; Deepened knowledge of engineering principles and efficient energy utilization; State-of-the-art examples for sustainable bioprocesses will be given which utilize agricultural residues, waste streams or synthesis gas, and, thus, protect the climate.

Intended Learning Outcomes:
The students are qualified to understand the fundamentals of design and calculations of biotechnological processes after the course. They will aquire knowledge of all aspects of process design.

Teaching and Learning Methods:
The module consits of lectures and tutorials. Contents of the lecture shall be imparted in speech and by presentation. In the exercises, performed as part of the module, learned theory shall directly be applied with a practical orientation by means of calculations and examples from

targeted aspects of bioprocess design. Additionally the students will be qualified by an in-depth knowledge of the design of unit operations including calculation of process parameters based on utilization of selected software tools (such as SuperPro Designer).

Media:
slides, interactive quizzes, scripts, practical exercises

Reading List:
Elmar Heinzle, Arno P. Biwer, Charles L. Cooney. Development of Sustainable Bioprocesses: Modeling and Assessment. Online ISBN:9780470058916

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

Courses (Type of course, Weekly hours per semester), Instructor:
Conceptual Design of Bioprocesses (Exercise) (Übung, 2 SWS)
Dsouza V, Zavrel M

Conceptual Design of Bioprocesses (Lecture) (Vorlesung, 2 SWS)
Zavrel M
For further information in this module, please click campus.tum.de or here.

Module Description

CS0017: Regulation of Microbial Metabolism | Regulation of Microbial Metabolism

Version of module description: Gültig ab winterterm 2023/24

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

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

Description of Examination Method:
The learning results are to be proved in form of a written test (60 min). The students demonstrate that they know relevant mechanisms of metabolic regulation and that they have understood the basic connections of microbial metabolism and its regulation dealt with in the module and can apply and transfer the methods and techniques.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Successfully completed exams for Cell- and Microbiology (CS0256) and Molecular Biology and Genetic Engineering (CS0257) modules or equivalent modules.

Content:
Relevant topics of metabolic regulation: i.a. catabolite repression, attenuation, autogenous regulation, end product inhibition, 2-component systems, quorum sensing, regulatory RNAs, stringent control, nitrogen regulation, iron homeostasis, phosphate regulation

Intended Learning Outcomes:
Upon successful completion of the module, students will be familiar with the principles and relevant mechanisms metabolic regulation, including the ecological significance of microbial metabolism. This knowledge is the essential basis for the design of microbial systems for production of chemicals and fuels based on biogenic resources, side and waste streams. In addition, students are able to transfer the knowledge they have acquired in order to develop solutions to new problems.

Teaching and Learning Methods:
The contents of the lectures are conveyed by a talk of the lecturer, based on ppt-presentations. The blackboard might additionally be used to explain more complex relationships. To a limited extent, this can be supplemented by self-study of the literature mentioned in the lecture. Learning methods: During the follow-up of the lecture, the students intensively deal with the teaching contents of the lecture.

Media:
PowerPoint, whiteboard

Reading List:
Microbiology – an evolving science, J. L. Slonczewski, J. W. Foster, W W Norton & Co Inc, 4th edition, ISBN: 978-0-393-61403-9
Molecular Biology of the Gene, I. D. Watson, T. A. Baker, A. Gann, M. Levine, Losick, Pearson, 7th edition, ISBN-13: 978-0321762436

Responsible for Module:
Blombach, Bastian; 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

CS0097: Advanced Environmental and Resource Economics | Advanced Environmental and Resource Economics

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:
The examination will be given in the form of a written examination. The students should be able to evaluate and justify general and detailed theories, methods and concepts of the environmental and resource economy. Important international examples will be explained. Type of examination: written, no additional tools allowed, duration of examination: 60 minutes

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Micro- and Macroeconomics

Content:
Many environmental issues, such as climate change, need to be considered globally. This course conveys concepts of optimal use of renewable and non-renewable resources in ex-ante viewing. In addition, the economics of water, energy markets, and natural resources such as fish and forest are deepened. Foundations of the New Institutional Economics illustrate the problem of the tragedy of common goods. Indicator systems such as Driver-Pressure-Stae-Impact-Response show the importance and complexity of environmental and sustainability measurement at national and international level.

Intended Learning Outcomes:
After attending the module, students will understand the role of renewable and non-renewable resources in the economy. Students can differentiate between the highest possible economic and sustainable return. They understand the functioning of energy and water markets. The students gain an understanding of the New Institutional Economy, especially land ownership and the sustainable use of public goods. In addition, students understand the measurement

of sustainability at the international and national level as well as the mathematical laws for the calculation of aggregated indices.

Teaching and Learning Methods:
The lecture and the seminar will be done by PowerPoint. In addition, articles from newspapers and journals are integrated into the lectures. In the seminar the students develop their own current case studies and discuss them from different perspectives based on the learned concepts and theories from the lecture. Classroom experiments are carried out for selected topics. Web lectures by internationally renowned experts and researchers will be integrated into the lecture.

Media:
Presentations, slide scripts, Articles, online lecture examples

Reading List:
Pearce, D. and R.K. Turner(1990). Economics of Natural Resources and the Environment. Johns Hopkins Univ Pr.
Tietenberg, T. and L. Lewis (2008). Environmental & Natural Resource Economics. Addison Wesley; 8 edition.

Responsible for Module:
Faße, Anja; 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

CS0102: Introduction to Game Theory | Introduction to Game Theory [IGT]

Version of module description: Gültig ab summerterm 2024

Module Level: Master	**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 (90 minutes). Students show the extent to which they have understood the taught game-theoretical definitions and terminology. They show to which extend they are able to use games in order to model problems from economics and engineering. They are also expected to apply important solution concepts to concrete games and answer comprehension questions concerning the properties and the advantages and disadvantages of the different solution concepts.

Repeat Examination:
End of Semester

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

Content:
Cooperative and non-cooperative games, solution concepts for cooperative games, core, Shapley value, solution concepts for non-cooperative games, pure Nash equilibria, mixed Nash equilibria, dominant strategies, Bayesian games, modeling concrete case studies related to sustainability as cooperative and non-cooperative games

Intended Learning Outcomes:
Students have aquired basic theoretical and practical knowledge on cooperative and non-cooperative games. They know the basic definitions and terminology and are able to model sustainability-related problems from economics and engineering as games. Students know the most important solution concepts for cooperative games (such as the core and the Shapley value) and non-cooperative games (such as Nash equilibria and dominant strategies). They have gained a good understanding of these concepts and are able to analyze concrete games by using them.

Teaching and Learning Methods:
Lectures introduce basic knowledge; tutorials practice modelling of application problems as games and applying solution concepts to concrete examples.

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

Reading List:
Manfred J. Holler, Gerhard Illing, Stefan Napel - Einführung in die Spieltheorie, 8. Auflage, Springer Gabler, 2019.
Steven Tadelis - Game Theory: An Introduction, Princeton University Press, 2013.
M. J. Osborne and A. Rubinstein - A Course in Game Theory, MIT Press, 1994

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

CS0149: Renewable Resources in Medicine | Renewable Resources in Medicine

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** 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 Assessment consists of a written examination (90 minutes)

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Requirements for the successful participation is basic knowledge in chemistry, cell and microbiology, biochemistry, materials science and renewable ressources

Content:
The course provides basic knowledge on the human anatomy, cell biology on general and the cell membranes in particular. The interaction of materials with cell surfaces and tissue will be introduced. The general issues related to pharmacology and the fabrication of drugs from from renewable ressources will be discussed. The application of renwable resources as the main course topic in surgery, internal medicine, plastic and reconstructive surgery as well as wound dressings will introduced. Future tasks for the medical application of renewable resources are outlined. The legislative framework for application of medical products and fabrication will be discussed.

Intended Learning Outcomes:
The successful visit of this course enables the students to select materials from renewable ressources for relevant fields in medicine (skin, muscle, bone) and can particularly assess the valueof their applicability. They are able to apply the most important legislation in medical application and to validate the material reqeuiements for the application in humans (biocompatibility). They are able to identify and develop new concepts for sustainable materials

from renwable ressources in medicine due to their aquired medical, chemical and materials science knowledge and they can set the base for the potiental application of such materials.

Teaching and Learning Methods:
Lecture (talk by teaching staff) with media, seminar on case studies

Media:
Presentation, script, examples, case studies

Reading List:
The following literature is recommended: Buddy Ratner et al.: Biomaterials Science - An Introduction to Materials in Medicine, Elsevier

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

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

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

Module Description

CS0170: Advanced Modelling and Optimization | Advanced Modelling and Optimization

Version of module description: Gültig ab winterterm 2021/22

Module Level: Master	**Language:** German/English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 7	**Total Hours:** 210	**Self-study Hours:** 150	**Contact Hours:** 60

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

Description of Examination Method:
The examination is based on two project works (each 50% of evaluation).

The project works examine the understanding of the modeling and programming techniques discussed in the course. The project works includes, appling algorithms to solve problems, creating mathematical models for examplary problems, and discuss presented results. By this the students have to demonstrate that they have understood and can apply the mathematical models and methods to solve planning problems. The project paper serves the assessment of the understanding of the modeling and programming language.

For the project paper the participants get a randomly assigned fictive, extensive decision problem. For this problem, the following has to be prepared:
- a modeling of the problem as a mathematical program, as well as explanation of the program
- an implementation of the program in a known optimization and programming language
- a verbal and graphical explanation of the of the results for the original problem

The grading of the project paper is done by the following criteria:
- Correctness of modeling and implementation as well as of the results (60% of examination)
- Clarity, comprehensibility and efficiency of the implementation (30% of evaluation)
- correct language, typesetting and outer form of the paper (10% of evaluation)

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Operations Research (CS0098)

Content:
This course is about modeling, solving and analyzing planning and decision problems using mathematial concepts. The course teaches the basics of linear, discrete and dynamic optimization. In addition, there is an introduction to optimization and corresponding programming languages, as well as teaching methods for analyzing and structuring algorithms, designing suitable object-oriented data structures, applying known standard algorithms and connecting them to other resources and programming environments.

Intended Learning Outcomes:
After successful completion of the module students are capable of modelling planning problems. Students learn to model real life business problems by applying mathematical programming techniques. They can independently implement mathematical models by using an optimization language and heuristical approaches. They are able to solve the models within the scope of a case study and can interpret the results. Furthermore, they deepen their knowledge in several different modeling techniques and basics of object oriented programming.

Teaching and Learning Methods:
The module consists of a lecture and exercise courses, which are provided weekly. In the lecture the content is jointly developed with the students mainly by using slides. The exercise course repeats parts of the lecture contents by using examples and offering the opportunitis to implement poblems individually. The excercises give the student the opportunity to pose questions and receive immediately help from the teaching assistant.

Media:
Script, Presentation slides

Reading List:
Hilier, F. and Lieberman, G., Introduction to Operations Research, McGraw-Hill, 2009
Popp, Andreas: Modellierung und Optimierung mit OPL. epubli, 2015
Schildt, H.: Java, A Beginner's Guide, 5th Edition, McGraw-hill, 2011
Winston, W.: Operations Research - Applications and Algorithms. 4th ed. (internat. student ed.), Belmont, Calif. (Duxbury), 2004.

Responsible for Module:
Alexander Hübner alexander.huebner@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

CS0177: Discrete Event Simulation | Discrete Event Simulation

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 7	**Total Hours:** 210	**Self-study Hours:** 135	**Contact Hours:** 75

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

Description of Examination Method:
The examination consists of two individual tasks and a project work. The individual work is done as homework and is composed as follows:
• R-Statistics homework (10 % of the evaluation)
• AnyLogic homework (10 % of the evaluation)

The project work serves to evaluate the understanding in handling and application of simulations. For the project work the participants receive a randomly assigned extensive fictitious simulation problem. The project work consists of the presentation of the project plan, a project report, an oral presentation of 20 min and a discussion time of 10 min.

The evaluation of the project work is based on the following criteria:
• presentation of the project plan (10 % of the evaluation)
• written documentation of the project work (50% of the evaluation)
• presentation and discussion of the project work (20% of the evaluation)

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge in mathematics and statistics, especially in probability theory and probability distributions as well as descriptive and inductive statistics

Content:
• Basics of simulation
• Steps in a Simulation Study
• Conceptual Modeling
• Introduction to ARIS: Representation of processes using event-driven process chains

• Data collection and modeling of input data
• Introduction to R: Analysis of distributions
• Modeling and implementation of simulation models
• Introduction to simulation software (e.g. AnyLogic) and basic as well as advanced simulation techniques
• Visualization of simulations
• Verification, Validation and Calibration of a simulation
• Methods for determining the simulation setting
• Statistical methods for the analysis of simulation results

Intended Learning Outcomes:
Students
• apply their knowledge of probability theory and probability distributions
• are able to analyze production and logistic systems, represent processes and design proposals for optimization.
• apply the necessary methodological knowledge for the independent execution of simulation studies.
• are able to apply simulation software such as AnyLogic practically.
• can present results of a simulation study and derive concrete recommendations for action from their analyses.

Teaching and Learning Methods:
The module consists of a lecture and an exercise, which take place weekly. In the lecture, the contents are derived together with the participants. The exercise repeats the lecture contents with examples and deepens core concepts through independent simulation and computational studies of selected problems. The students are supported in solving the exercises by the tutors.

Media:
Presentations, cases and solutions

Reading List:
• Kelton, W. D., R. P. Sadowski, and D. T. Sturrock, Simulation with Arena, 3. Aufl., Boston (McGraw-Hill) 2003.
• Law, A. M. and W. D. Kelton, Simulation Modeling and Analysis, 4. Ed., Boston (McGraw-Hill) 2007.

Responsible for Module:
Alexander Hübner

Courses (Type of course, Weekly hours per semester), Instructor:
Discrete Event Simulation (Exercise) (Übung, 2 SWS)
Schäfer F [L], Schäfer F, Tuma N

Discrete Event Simulation (Lecture) (Vorlesung, 2 SWS)
Schäfer F [L], Schäfer F, Tuma N
For further information in this module, please click campus.tum.de or here.

Module Description

CS0184: Advanced Sustainability and Life Cycle Assessment | Advanced Sustainability and Life Cycle Assessment

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** 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:
Written exam (90 minutes): Students have to solve problems from the thematic field of the module. They have to prove their ability to use the right vocabulary, apply their knowledge on advanced topics in life cycle and systems thinking, sustainability and and life cycle assessment. Learning aids: pocket calculator.

Alternative: For small groups (<15 students) parts of the exam can be held in case studies which have to be solved in a group. Thereby the students have to prove through the solution of an advanced problem that they are capable to apply methods and approaches of sustainability and life cycle assessment to emerging topics from the field. Weighting: 1:1.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
-

Content:
The module contains units covering the following topics:
• Systems and life cycle thinking
• LCA following the ISO 14040/14044 and ILCD standards
• Extension of Life Cycle Assessment to Life Cycle Sustainability Assessments
• Advanced Life Cycle Impact Assessment Methods such as for
- Land use and land use change
- Water use
- Resource use
• Attributional and consequential assessments

• Regionalisation of inventories and impact assessments
• Hybrid approaches
• Uncertainty handling
• Interface with Multi Criteria Decision Analysis
• Presentation and visualisation of results
• Handling of data uncertainty
• Current trends and developments
• Software systems and data bases for material flow analysis and life cycle assessment
• Case studies

Intended Learning Outcomes:
The students use advanced concepts and tools of sustainability and life cycle assessment to assess products, services and processesregarding their environmental impacts. Thus, they are able to gain a deeper understanding of their underlying material and energy flows and how they impact the environment. With these competencies development and improvement of systems, products and services can be supported, decision support delivered and communication with stakeholders aided.

Teaching and Learning Methods:
Format: lecture and (computer-based) 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 with presentation
- Individual assignments and presentation
- Computer lab exercises using LCA software systems and Life Cycle Inventory Data bases.

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

Reading List:
Recommended reading:
• Curran, M.A. (2015): Life Cycle Assessment Student Handbook, Scrivener Publishing:
• Hauschild, M.Z. & Huijbregts, M.A.J. (2015): Life Cycle Impact Assessment (LCA Compendium - The Complete World of Life Cycle Assessment), Springer.
• Klöpffer, W. & Grahl, B. (2014): Life Cycle Assessment (LCA), Wiley-VCH.
• Recent articles from esp. International Journal of Life Cycle Assessment, Journal of Cleaner Production, Journal of Industrial Ecology, Environmental Science and Technology (to be announced in the lecture)

Responsible for Module:
Prof. Magnus Fröhling

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

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

Module Description

CS0219: Protein-based Materials for Technology | Protein-based Materials for Technology

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/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. The students should demonstrate an understanding of the lecture content and its applications to problems related to proteins-based materials in the exam. No auxiliary means are allowed in the exam. 120 min examination time.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
This course will intend to consolidate concepts in Physics, Mechanics, Physical Chemistry, Biology, Engineering, and Chemistry having the focus on articles describing protein-based materials and their used in technological platforms. As such, knowledge in Physics, Chemistry, Mechanics, and Biology is required.

Content:
The module aims to provide in-depth knowledge to the students in physical chemistry, spectroscopy, thermodynamic, protein structure, and optoelectronics applied to protein-based materials. The module will study scientific articles that describe protein-based materials. The first focus will be on extracting information about the structure-functionally relationship of proteins and their interaction with other molecules and macromolecules and the different techniques used for that purpose. The second focus will be on studying how protein-based materials can have applications outside the typical biology range.
The course will study at least one scientific article per session to cover protein-based materials with applications in optoelectronics, medicine, and chemistry.
Each topic will be addressed, refreshing the most important physicochemical principles and more useful techniques followed by their relevance in these materials' structural and functional aspects and their application.

Intended Learning Outcomes:
At the end of the module, the students will be able i) to critically evaluate the information in scientific articles relating to novel protein-based materials for technology; ii) to analyze protein-based materials using a physicochemical perspective; iii) to describe the different ways protein interact with other molecules or macromolecules to form functional materials; iv) to describe the main role and characteristics of protein-based materials in technological platforms. They will be able to examine the structure of proteins and other molecules and macromolecules and the forces that define their functionality. They will be able to apply these concepts in bio-based and bio-inspired technologies.

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

Media:
The following forms of media apply: script, powerpoint, films, and blackboard

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

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

Courses (Type of course, Weekly hours per semester), Instructor:
Protein-based materials for technology (Vorlesung, 2 SWS)
Costa Riquelme R [L], Costa Riquelme R, Atoini Y, Banda Vazquez J

Protein-based materials for technology (Exercise) (Übung, 2 SWS)
Costa Riquelme R [L], Costa Riquelme R, Atoini Y, Banda Vazquez J
For further information in this module, please click campus.tum.de or here.

Module Description

CS0228: Technology and Management of Renewable Energies in a Global Context | Technology and Management of Renewable Energies in a Global Context [REAE]

Version of module description: Gültig ab summerterm 2024

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

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

Description of Examination Method:
The exam will be in form of an oral presentation of the students (20+10 minutes; 75% of the grade) and a short report of the students' project work (max. 5 pages, not counting front page and cited literature; 25% of the grade).

In this students' project, the students demonstrate understanding of specific questions related to a defined topic concerning the technology and management of renewable energies in a global context. Students have to show in their presentation that they can analyse, solve and answer defined problems and questions related to this topic. Participants of the course show that they have done appropriate research work and are able to present their results. By answering follow-up questions related to their presentation they show that they have learned to put their research outcome into the relevant technical or country context. The presentation slides and the short report will be handed over to the lecturers and will be included in the grading.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic know-how related to specific techniques of renewable energies (e.g. solar energy, wind energy, hydropower, biomass conversion technology, geothermal energy) as well as management of energy systems either on a company or on state level.

Content:
A) Technical aspects of different forms of renewable energies (e.g. current state of technology, technical options for the future, technical bottlenecks, scale-up possibilities)
- Wind power

- Hydropower
- Photovoltaics, solarpower
- Geothermal energy
- Biomass use for energy purposes
- Biofuels, electric vehicles, E-fuels
- Hydrogen
- Other forms of renewable energies

B) Economic aspects related to defined renewable energies (e.g. cost of use/production, cost structure and development in the past, learning curves, innovation and diffusion of renewable energies)
C) Influencing factors for adoption and use of renewable energies (e.g. natural/local conditions, availability of renewable resources, technical infrastructure, user structure of energy, cost and economic factors, financing, political and regulatory issues, social acceptance, behaviour of stakeholders and people)
D) Situation and development in a specific (country) context (e.g. governance, policy goals and activities, competing factors and interests (e.g. by fossil energy use or related companies/ stakeholders), legal and regulatory stability)

Intended Learning Outcomes:
At the end of the module, students will be able to analyse and elaborate solutions for existing problems related to the technology and management of renewable energies and apply such solutions to the specific context of selected countries worldwide. They consider both the technical side as well as the economic and management dimension in order to develop integrated solutions for a specific question related to renewable energies. Additionally they take the specific context and situation (e.g. technical infrastructure and know-how, maintenance, electrical or other grids, political and regulatory rules, economic framework, company and user structure) in one or several countries or regions into account when analysing and elaborating solutions for the question on-hand. They are able to apply their knowledge to create an oral presentation and a written summary of their findings. Presented results are discussed with the audience so that students are able to defend their solution and put it in an appropriate context.

Teaching and Learning Methods:
The module is a seminar, where course participants form (preferably international) teams that investigate a given topic by autonomously doing research work and discussing results within the team. During regular meetings with the lecturers questions can be discussed, next steps are defined and (interim) results are presented. Lecturers will provide basic and background material for the students as well as actual information for the given topics that are elaborated by the student teams.

Learning activities: Literature/document research, student group project

Media:
Presentation slides, online discussion forum (all lecture materials are available via Moodle)

Reading List:
Specific literature and documents will be provided to the topics that are worked on in the student projects

Responsible for Module:
Menrad, Klaus; Prof. Dr.sc.agr.

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

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

Module Description

CS0254: Introduction to Management of Renewable Resources | Introduction to Management of Renewable Resources

Version of module description: Gültig ab summerterm 2024

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

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

Description of Examination Method:
The examination is a written exam (120 minutes). The students demonstrate that, within a limited time and without tools, the economic relationships involved in the use of renewable raw materials have been understood and can be analyzed and further developed in connection with individual company activities. The exam also examines the extent to which the students can characterize the various markets for renewable raw materials and show possible solutions for material and energetic use.

The lecture and exercise "Economics of Renewable Resources" accounts for 65% and the lecture "Markets for Renewable Resources" for 35% of the overall grade.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:

Content:
The lecture is divided into 3 parts. Although these are independent of each other in terms of content, they address different facets of the economy of renewable resources.

1. Lecture Economics of Renewable Resources
Introduction to the basics of economics using selected conversion paths based on renewable raw materials, from location decisions to procurement and logistics, production, inter-company connections to external reporting.

2. Lecture Markets of Renewable Resources

Presentation of different markets for renewable raw materials. These are divided into material use (bio-lubricants, materials, base chemicals and fine chemicals) and energetic use (heat, electricity and mobility).

3. Exercise Economics of Renewable Resources
The content of the lecture is to analyze and critically evaluate the economics of renewable resources using case studies, so that the participants can independently develop the content further based on the content of the lecture.

Intended Learning Outcomes:
After completion of the module, the students can apply the economic principles of using renewable raw materials in a differentiated manner and analyze and evaluate the economics using case studies from individual companies. Furthermore, they are able to critically assess the business and market relationships in the utilization of renewable raw materials and to include current developments. In addition, the students can assess and compare the different forms of marketing and market sizes of renewable raw materials.

Teaching and Learning Methods:
Lecture; discussions; case studies
With the help of the lectures and exercises, all sub-areas of the module are presented. With the help of this method, the extensive volume of material can be communicated in the best way. In the discussions, the students learn to integrate different perspectives and to correctly classify and critically assess the module content.

Media:
Presentations, script, case studies

Reading List:
Wacker, H., Blank, J. E.: Ressourcenökonomie, Bd. 2 Einführung in die Theorie erschöpfbarer natürlicher Ressourcen, München, Oldenbourg Verlag, 1999.;
KALTSCHMITT, M. und H. HARTMANN (Hrsg.): Energie aus Biomasse. Grundlagen, Techniken und Verfahren. Springer Berlin, 2009;
Vahs, D., Schäfer-Kunz, J.: Einführung in die Betriebswirtschaftslehre. Schäffer-Poeschel Verlag Stuttgart. 2012

Responsible for Module:
Röder, Hubert; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Overview Markets of Renewable Resources (Lecture) (Vorlesung, 1,5 SWS)
Decker T

Management of Renewable Resources (Exercise) (Übung, 1 SWS)
Röder H

Management of Renewable Resources (Lecture) (Vorlesung, 1,5 SWS)
Röder H [L], Pokholkova M, Röder H
For further information in this module, please click campus.tum.de or here.

Module Description

CS0298: Applied Ethics for Renewable Resources | Applied Ethics for Renewable Resources

Version of module description: Gültig ab winterterm 2024/25

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

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

Description of Examination Method:
In a written examination (60 minutes), students relate on fundamental approaches to bioethics. Social issues will translate into students' tasks. Students thereby demonstrate the connections between risks and injustice. Drawing on special scenarios, students will identify areas of conflict and propose possible solutions.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
Definition of ethics terminology, main schools of thought in approaches to bioethics such as Kantian ethics / deontological ethics
Utilitarianism (theory of consequentialism), liberal individualism (rights-based theory), communitarianism (community-based theory); how bioethical issues are perceived in society, such as
-red gene technology
-green gene technology
-Areas of conflict based on the use of renewable resources: "food before fuel" slogan, exploitation of agricultural land for chemical products or for re-use as energy in light of the world's hunger epidemic. This module will also discuss food waste along the value chain from field to fork.
Legislation laid down in the Convention on Biomedicine (Council of Europe); selected areas of contention such as bioethics for all living creatures; human bioethics; definition of life; definition of death; medical ethics; research; exploitation of resources (production); resource waste (efficiency)

Intended Learning Outcomes:
After completion of the module, students will understand the fundamentals of bioethics. They will be able to gather information on the main schools of thought in approaches to bioethics. Students will have formed their own opinions on aspects of the social issues covered. They will be able to identify issues arising from the production of renewable resources and propose possible solutions using methods learnt in class.

Teaching and Learning Methods:
Lectures teach basic knowledge, presentations, tutorials on practical approches in bioethics, expert lectures on selected topics related to the ethical evaluation of using renewable resources

Media:
script, PowerPoint presentation, documentaries, group work

Reading List:
"Günter Altner: Naturvergessenheit. Grundlagen einer umfassenden Bioethik. WBG, Darmstadt 1991 ISBN 3534800435;
Suhrkamp Taschenbuch Wissenschaft Nr. 1597: Bioethik - Eine Einführung Taschenbuch – 2003 von Marcus Düwell (Herausgeber, Vorwort), Klaus Steigleder (Herausgeber, Vorwort)
European Union, 2014, Health and Consumers. Food. Stop Food Waste. European Commission. Http://ec.europa.eu/food/food/sustainability/index-en.htm [acessed June 6, 2014]
Agrarethik: Landwirtschaft mit Zukunft Gebundene Ausgabe – Juli 2012
von Uwe Meier (Herausgeber)
Energie aus Biomasse - ein ethisches Diskussionsmodell - Michael Zichy, Christian Duernberger, Beate Formowitz, Anne Uhl, Maendy Fritz, Edgar Remmele, Stephan Schleissing, Bernhard Widmann (2011): ""Energie aus Biomasse - ein ethisches Diskussionsmodell"". Darmstadt, Vieweg +Teubner, ISBN: 978-3-8348-1733-4"

Responsible for Module:
Andrea Potzler

Courses (Type of course, Weekly hours per semester), Instructor:
Applied Ethics for Renewable Resources (Exercise) (Übung, 1 SWS)
Potzler A

Applied Ethics for Renewable Resources (Lecture) (Vorlesung, 1 SWS)
Potzler A
For further information in this module, please click campus.tum.de or here.

Module Description

MGT001348: Innovation Sprint | Innovation Sprint

Version of module description: Gültig ab summerterm 2022

Module Level: Bachelor	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 140	**Contact Hours:** 40

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

Description of Examination Method:
Combination of group and individual project assignment - final examination consists of two components, each carrying 50% of the final course grade: (1) a 5 minute group presentation plus 10 minutes Q&A and feedback at the end of the course and (2) an individual reflection paper of ca. 2,500 words.
Students will present to the class, the lecturer and the partner how the team identified an attractive opportunity in a suitable market, understood the customers' / users' needs in the process and, as a result, proposed a sustainable business model that balances people, planet and profit.

In a written reflection paper, every student will reflect upon and consolidate their individual learnings from (1) the reading package and (2) their entrepreneurial experience on three different levels - self, team and entrepreneurship.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Interest in entrepreneurship and sustainability, ability to work in a team

Content:
Supported by the reading package students will work on five intensive days in Campus only in interdisciplinary teams on a challenge from a partner and learn why and how to develop customer and user centric business ideas through applying an entrepreneurial mindset and innovative methods - always considering the triple bottom line.
Taking on an embedded view on the interrelatedness of economic, social and environmental systems, students will develop an ecosystem map to get an overview of relevant stakeholders and potential customers as well as important relationships and value streams. Input on Empathy

Research will prepare them to collect qualitative insights from potential customers and users through interviews, immersion and contextual observations.
After conducting their Empathy Research they will step by step learn how to synthesize their insights and define opportunities for sustainable innovation. With a concrete how-might-we-question they will start into ideation. Through different creativity methods they will develop and prioritize ideas and build a simple prototype. This prototype is being tested again through qualitative tests with potential customers and users. When they come back after testing they do a first iteration based on the feedback they got and derive assumptions on a potential business model. After input on pitching they will prepare slides or other material and pitch in front of the group, partner and external guests. After the pitch event they will be led through a reflection of the learnings they gained during the week. The reading package will support the transfer of these learnings.

Intended Learning Outcomes:
After participating in this module students will be able to understand and apply life-centered design principles in the early stages of an entrepreneurial process: from identifying an entrepreneurial opportunity and understanding its environmental and social impact to validating assumptions by applying qualitative research methods and interpreting data as well as using prototyping as a tool for communication and learning. They will be able to apply creativity methods, take over collective responsibility and know how to effectively communicate their business opportunities.
Taking decisions under uncertainty, ambiguity and risk in newly formed teams will foster their collaboration and communication skills and prepare them for future team work in appreciating and accommodating team members' individual personalities and boundaries.
At the same time the reading package enables students to gain a broader understanding of the methods learned in the course providing them with the ability to apply them beyond the context of innovation.

Teaching and Learning Methods:
This module relies on a combination of readings, input sessions, workshops, teamwork and individual feedback and support. While input sessions will stimulate students’ engagement with relevant tools and topics, workshops and team discussions will support the implementation of the knowledge in their projects and facilitate students’ learning of the soft and intricate aspects of adopting an entrepreneurial mindset and skills. Working on a design challenge that a partner (e.g. TUM Venture Labs) provides stimulates peer competition and allows students to directly apply what they learn in a real life setting. The reading package will strengthen students' understanding of the methods and allow them to make sense of their practical experience.

Media:
Presentations, canvas, handywork

Reading List:
Each semester students will be provided with a mandatory reading package.

Responsible for Module:
Alexy, Oliver; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Innovation Sprint (MGT001348, englisch) (Seminar, 4 SWS)
Alexy O [L], Hagleitner F
For further information in this module, please click campus.tum.de or here.

SZ0003-11: Intercultural Communication | Interkulturelle Kommunikation

Module Description

SZ1102: EuroTeQ Intercultural Workshop – Intercultural competencies for working in multicultural teams | EuroTeQ Intercultural Workshop – Intercultural competencies for working in multicultural teams

Version of module description: Gültig ab summerterm 2022

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

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

Description of Examination Method:
1 written test 90 min. (100%)

Performance, testing the learning outcomes specified in the module description, is examined by a written test. Aids are permitted. Candidates work on tasks that focus on intercultural theories, intercultural models and other content covered in class. As part of the exam, students must prove their intercultural reflection skills by

Repeat Examination:

(Recommended) Prerequisites:
The course is especially intended for students in engineering programs, but is generally open to all TUM students. In particular, students who will be studying at a EuroTeQ partner university in the coming academic year or those, who are from partner universities and are currently studying at TUM and/or are participating in the EuroTeQ program should feel addressed. Students should envision themselves working in a European engineering context.

Content:
The workshops take place on 3-4 days in the specified period. One Workshop on Fridays / Saturdays and one on Mondays / Thursdays.
In addition to their specialist knowledge, future engineers must coordinate cross-disciplinary work and communicate with other disciplines. Accordingly, in a European job market, intercultural competencies and communication skills are required to create successful collaboration.

Intercultural agility, which is essential for studying and working in a multicultural environment, consists of a combination of knowledge about intercultural contexts and an ability to critically analyze one's own thoughts and values from an intercultural perspective After the course, students can apply intercultural models and strategies based on these models for the practical management of complex, interculturally challenging situations in university and professional settings.

Intended Learning Outcomes:
Students can recognize how intercultural factors can play a role when working in multicultural teams and how our ways of thinking, values, attitudes and our personal background influence the way we interact with others. They have acquired tools for analyzing and interpreting interculturally complex situations in a goal-oriented manner and have discourse strategies to implement these in discussions in order to facilitate mutual understanding. Students can expand their own knowledge of divergent cultural values and standards by asking purposeful and appropriate questions and they can present their own perspective.

Teaching and Learning Methods:
The module consists of a course in which the learning content is studied in a communicative and action-oriented manner using self-experience exercises, video material, critical incidents and theoretical input in individual, partner and group work. Additional self-study material is provided (for preparation and follow-up work and for deepening one's own background knowledge) for consolidation and supplementation of the classroom sessions.

Media:
Multimedia-supported teaching and learning material, also online

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
The EuroTeQ Engineer: Cultural Agility for Studying and Working in Multicultural Settings (Workshop, 1 SWS)
Elekes R, Nierhoff-King B
For further information in this module, please click campus.tum.de or here.

Nawaro in Communication and Didactics | Nawaro in Kommunikation und Didaktik

Module Description

CS0258: Nawaro in Communication and Didactics | Nawaro in Kommunikation und Didaktik

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**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:
Im Laufe des Semesters wird von den Studierenden als Studienleistung die Ausarbeitung von Präsentationen, Teilnahme an Rollenspielen und Fallbearbeitungen in der Gruppe mit Videoanalysen erwartet (unbenotet). Die benotete Prüfungsleistung wird in zwei Teilen erbracht. Der erste Teil ist eine bewertete Lehrveranstaltung (Präsentation: 20 min) in Gymnasien und anderen weiterführdenen Schulen, bei der die erworbenen didaktischen Fähigkeiten angewendet werden sollen (80 % der Note). Der zweite Teil der Prüfung besteht aus einem schriftlichen Bericht (ca. 10 Seiten) bezüglich der durchgeführten Lehrveranstaltung am Gymnasium (20 % der Note).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
keine

Content:
Vermittelt werden Grundlagen der Kommunikation und Didaktik, Kommunikationsmethodik, Kommunikationsregeln und deren Anwendung im Berufsalltag sowie zielorientierte Gesprächsführung. Außerdem werden Ausdruck und Sprache, Darstellung des Studienganges, Darstellung der Inhalte und deren praktische Vermittlung, die Organisation von Unterrichtseinheiten an den involvierten Schulen, die Charakterisierung des Unterrichtsbedarfs und Belange der Öffentlichkeitsarbeit behandelt.

Intended Learning Outcomes:
Nach der Teilnahme am Modul können die Studierenden grundlegende Beratungs- und Kommunikationsmodelle analysieren und die dahinterliegende Theorie den Modellen entsprechend zuordnen.
Des Weiteren können die Studierenden anhand von Fallbeispielen Beratungs- und Kommunikationsmodelle anwenden.
Darüberhinaus überprüfen sie ihre eigene Grundhaltung und reflektieren ihr eigenes Beratungs- und Kommunikationsverhalten. Die Studierenden können Lernziele passend zur jeweiligen Zielgruppe und zu den jeweils zu vermittelnden Inhalten formulieren und definieren.
Sie können entlang der Lernziele eine Unterrichtseinheit zeitlich in eine sinnvolle Reihenfolge bringen und können entsprechende Unterrichtsmethoden passend zu den Zielen auswählen.
Sie können einen Lehrplan für Ihre Unterrichtseinheit gestalten und auch umsetzen. Des weitern können die Studierenden ihre inhaltlichen Themen verbindlich erläutern und sie in Verbindung setzen mit den Arbeitsfeldern des Wissenschaftszentrums.Sie können den inhaltlichen Bedarf der Schule analysieren und den Unterrichtsumfang planen und sie sind befähigt Presse- und Öffentlichkeitsarbeit mit Inhalten und Intention aus dem Bereich Nachwachsender Rohstoffe zu koordinieren.

Teaching and Learning Methods:
Neben der Vorlesung werden Übungen, Rollenspiele, Fallstudien und Exkursionen und in Videoanalysen werden Einzel- und Gruppenpräsentationen durchgeführt und ananlysiert.
Außerdem findet eine Lehrprobe vor einer Schulklasse eines Gymnasiums der Region statt.

Media:
Präsentationen, Skriptum, Video, Übungsblätter, Flipchart,
Powerpoint, Filme zeigen, Anschauungsobjekte (nachwachsende Rohstoffe), Fallbeschreibungen, Schultafel, Powerpoint

Reading List:
Schulz von Thun, F. (2019). Miteinander reden 1-4: Störungen und Klärungen. Stile, Werte und Persönlichkeitsentwicklung. Das "Innere Team" und situationsgerechte Kommunikation. Fragen und Antworten. Hamburg: Rowohlt Verlag.

Lippitt, G. & Lippitt, R. (2015). Beratung als Prozess: Was Berater und ihre Kunden wissen sollten. Leonberg: Rosenberger Fachverlag.

Weisbach, C.-R., Sonne-Neubacher, P. & Praetorius, I. (2015). Professionelle Gesprächsführung: Ein praxisnahes Lese- und Übungsbuch. München: Deutscher Taschenbuch Verlag.

Berger, F. (2012). Personenzentrierte Beratung. In J. Eckert, E.-M. Biermann-Ratjen & D. Höger (Hrsg.). Gesprächspsychotherapie. Lehrbuch für die Praxis (S. 279-309). Berlin: Springer."

Responsible for Module:
Claudia Martin

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

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

Master's Thesis | Master's Thesis

Module Description

CS0144: Master's Thesis | Master's Thesis

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 30	**Total Hours:** 900	**Self-study Hours:** 450	**Contact Hours:** 450

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

Description of Examination Method:
The module examination consists of the preparation and positive evaluation of the Master´s Thesis (depending on selection of topics 25 to 75 pages).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
70 credits including all compulsory modules of the Master's program

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

Intended Learning Outcomes:
After completion of the module, the students are able to work self-reliant on complex 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 Master’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:
Alle prüfungsberechtigten Dozenten/innen des Studiengangs des Studienganges Technology of biogenic resources

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

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

Alphabetical Index

A

B

C

D

E

F

G

H

I

L

M

N

P

R

S

T

W