Subdivided Module Catalogue
for the Subject
MINT Teacher Education PLUS, Elite
Network Bavaria (ENB)
with the degree "LA Master Gymnasium"
(120 ECTS credits)

Examination regulations version: 2016
Responsible: Faculty of Biology
Responsible: Faculty of Chemistry and Pharmacy
Responsible: Faculty of Mathematics and Computer Science
Responsible: Faculty of Physics and Astronomy
Course of Studies - Contents and Objectives

The elite degree programme „MINT-Lehramt PLUS“ in the Elite Network of Bavaria is a research-oriented Master's degree programme offered by the Faculty of Biology, the Faculty of Chemistry and Pharmacy, the Faculty of Mathematics and Computer Science and the Faculty of Physics and Astronomy of the Julius-Maximilians-Universität Würzburg.

It is being offered as part of a Bachelor’s and Master’s study model. This Master’s degree is an additional professional and research-oriented degree.

The elite Master’s programme prepares graduates for a job in the professional fields of education and science. Therefore competences in four different areas are acquired: deepening of a STEM subject (60 ECTS credits), deepening of subject didactics (10 ECTS credits), international, interdisciplinary research (10 ECTS credits) and profession specific key competences (10 ECTS credits). The elite Master programme is completed by a Master thesis (30 ECTS credits).

Graduates have deepened knowledge in one chosen STEM subject. They know current concepts, topics and fields of research as well as research methods of the subject and use this knowledge especially to critically reflect and interpret scientific sources. Graduates apply their knowledge of the subject and its methods to recognise subject related problems, to develop solution approaches, to solve problems and to critically reflect their approach afterwards. In doing so, they act self-organised and independently.

Graduates have deepened knowledge in the didactics of a STEM subject respectively STEM subjects chosen by them. This involves current concepts, topics, results of national and international research as well as specific research methods. They can transfer their knowledge to school and class and, against this background, they can critically reflect school-based activities. Graduates are able to evaluate new research results and to classify them in respect to their current knowledge.

Graduates are able to plan and to conduct research projects self-organised and independently and critically reflect them in the light of current research. In doing so they use their knowledge in special branches of science and/or subject didactics. Moreover, graduates have competences to work on problems interdisciplinarily and cooperatively.

Graduates have deepened knowledge and abilities in the field of key competences, that are of specific importance for a job in the professional fields of education and science.
Abbreviations used

Course types: E = field trip, K = colloquium, O = conversatorium, P = placement/lab course, R = project, S = seminar, T = tutorial, Ü = exercise, V = lecture

Term: SS = summer semester, WS = winter semester

Methods of grading: NUM = numerical grade, B/NB = (not) successfully completed

Regulations: (L)ASPO = general academic and examination regulations (for teaching-degree programmes), FSB = subject-specific provisions, SFB = list of modules

Other: A = thesis, LV = course(s), PL = assessment(s), TN = participants, VL = prerequisite(s)

Conventions

Unless otherwise stated, courses and assessments will be held in German, assessments will be offered every semester and modules are not creditable for bonus.

Notes

Should there be the option to choose between several methods of assessment, the lecturer will agree with the module coordinator on the method of assessment to be used in the current semester by two weeks after the start of the course at the latest and will communicate this in the customary manner.

Should the module comprise more than one graded assessment, all assessments will be equally weighted, unless otherwise stated below.

Should the assessment comprise several individual assessments, successful completion of the module will require successful completion of all individual assessments.

In accordance with

the general regulations governing the degree subject described in this module catalogue:

ASPO2015

associated official publications (FSB (subject-specific provisions)/SFB (list of modules)):

14-Sep-2016 (2016-97) except mandatory electives 08-OCM-NAT-172, 08-BC-MOLP-172, 08-MCM3-172, 11-MRI1-171, 11-SSC-172, 11-STRG1-171, 11-STRG2-171 added in Fast Track procedure at a later time

20-Dec-2017 (2017-72) except mandatory electives 08-OCM-NAT-172, 08-BC-MOLP-172, 08-MCM3-172, 11-MRI1-171, 11-SSC-172, 11-STRG1-171, 11-STRG2-171 added in Fast Track procedure at a later time

14-Mar-2018 (2018-19)

This module handbook seeks to render, as accurately as possible, the data that is of statutory relevance according to the examination regulations of the degree subject. However, only the FSB (subject-specific provisions) and SFB (list of modules) in their officially published versions shall be legally binding.
In the case of doubt, the provisions on, in particular, module assessments specified in the FSB/SFB shall prevail.
The subject is divided into

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**Module Area A: Focus Subject-based Didactics (10 ECTS credits)**

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**Module Area C: International, interdisciplinary research (10 ECTS credits)**

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### Module Area D: Subject specific key skills (10 ECTS credits)

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### Module Area E: Master Thesis (30 ECTS credits)

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<td>Dean of Studies Biologie (Biology)</td>
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**Contents**

Timing matters: Temporal organisation in the animal kingdom. Timing plays an important role in all living systems. Animals make use of endogenous clocks to predict and adapt to daily or seasonal changes in environmental parameters. To be at the right place at the right time is of great fitness relevance if, for example, a mating partner or enough food has to be found. Many mutualistic, antagonistic or social interactions can only take place if animals are at the same place at the same time and in the appropriate developmental stage. The lecture gives an introduction to the mechanisms underlying the temporal organisation in the animal kingdom. Adopting an integrative approach, the lecture goes from timing mechanisms on the neuronal level to individual behaviour and then to interactions in social groups, populations or partners in complex and variable ecosystems.

**Intended learning outcomes**

Students get to know the advantages of an integrative approach when analysing complex biological systems. They learn to relate and integrate different fields within biology. In the seminar, students practise the discussion of research findings.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3)

Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module title | Endogenous Clocks
---|---
Abbreviation | 07-MS1CB-152-m01

Module coordinator | holder of the Chair of Neurobiology and Genetics
Module offered by | Faculty of Biology

| ECTS | 10 |
| Method of grading | numerical grade |
| Only after succ. compl. of module(s) | -- |

| Duration | 1 semester |
| Module level | graduate |
| Other prerequisites | -- |

Contents

Introduction into endogenous clocks of unicellular organisms, fungi, plants and animals, with a focus on the neuronal organisation of the clock in the brain of mammals and insects. The biological functions of endogenous clocks and the underlying mechanisms will be discussed on the molecular, cellular and organismic levels. It will be explained how clocks adjust to a 24h day with variable photoperiods. Applied aspects regarding e. g. shift work or jetlag will also be discussed.

Intended learning outcomes

The students learn fundamental principles underlying chronobiology/endogenous clocks and obtain an insight into current research in the field. In the seminar, they practise their presentation skills and the discussion of research findings in English.

Courses (type, number of weekly contact hours, language — if other than German)

V (2) + S (1)
Module taught in: English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)
Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Neuromodulation and Neuronal Development

Abbreviation: 07-MS1NMND-152-m01

Module coordinator: holder of the Chair of Neurobiology and Genetics

Module offered by: Faculty of Biology

ECTS: 10

Method of grading: numerical grade

Duration: 1 semester

Module level: graduate

Other prerequisites: --

Contents:

Neuromodulation: cellular and molecular biology of neuromodulators and their receptors, modulation of synaptic transmission and membrane potential, theoretical and functional aspects of neuromodulation, model systems used to study modulation of neuronal circuits. Fundamental principles of molecular developmental neurobiology. Focus is on the establishment of the neuroectoderm, pattern generation and regional specification, neuronal precursors, neuronal growth, differentiation of neurons, axonal pathfinding, neuronal connectivity.

Intended learning outcomes:

The students learn fundamental principles underlying neuromodulation and neuronal development and obtain an insight into current research in the field. In the seminar, students practise presenting and discussing research findings in English.

Courses:

- Type: V (2) + S (1)
- Number of weekly contact hours: 3
- Language: English

Method of assessment:

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

Allocation of places:

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Additional information:

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Referred to in LPO I:

(examination regulations for teaching-degree programmes)

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**Contents**

To understand how the brain controls behaviour is at the heart of neuroscience. Both brain and behaviour can be overwhelmingly complex and plastic, yet neurogenetic methods are powerful tools to dissect the principles of how the brain controls behaviour. The lecture and seminar will give a state-of-the art view on current and important topics of behavioural neurobiology (incl. e.g. sleep, control of appetite and feeding, social behaviour, mating, mirror neurons, molecular mechanisms of auditory-guided behaviour, neurogenetic techniques) focusing on genetic model systems such as the fruit fly Drosophila, the mouse, and the nematode C. elegans.

**Intended learning outcomes**

In the lecture, students acquire theoretical and methodological insights into current topics in the field of neurogenetics in general and the neurogenetics of behaviour. In the seminar, students practise presenting and discussing research findings in English.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (1)

Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Module coordinator**
holder of the Chair of Neurobiology and Genetics

**Module offered by**
Faculty of Biology

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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
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**Contents**
A current topic in the field of neurobiology will be investigated. The practical course will be offered in different specialisations: molecular, clinical, cellular, developmental or behavioural neurobiology or in neurogenetics. In addition to a literature search, a variety of neurobiological methods (for example: electrophysiology, immuno-histochemistry, molecular biological techniques, clinical and neurogenetic techniques) and different model systems are offered. The experimental results will be documented and presented in the form of a scientific talk, a publication or a seminar paper.

**Intended learning outcomes**
The participants are able to conduct scientific research within the field of neurobiology. They have acquired the knowledge and skills (e.g. basic and advanced knowledge, special knowledge, advanced methodological background, general and specific methods) to carry out and document neurobiological experiments according to best practice.

**Courses**
(type, number of weekly contact hours, language — if other than German)
P (14) + S (1)
Module taught in: German and/or English

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)
Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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<td>Faculty of Biology</td>
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<td>1 semester</td>
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### Contents

The students will independently work on a smaller project within a current line of research at the Chair. Neurobiological, genetic or molecular techniques will be tested and adapted according to the research aim. The progress of the experiments and the current line of research will be documented and presented in the form of a scientific talk, a publication or a seminar paper.

### Intended learning outcomes

The participants are able to independently conduct scientific research within the field of neurobiology and to adapt a research plan according to the experimental progress. They have acquired the knowledge and skills (e.g. basic and advanced knowledge, special knowledge, advanced methodological background, general and specific methods) to independently carry out, document and interpret neurobiological experiments according to best practice.

### Courses (type, number of weekly contact hours, language — if other than German)

P (29) + S (1)
Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)
Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Module title
Animal Ecology and Tropical Biology

### Abbreviation
07-MS1TÖ-152-m01

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### Contents
This module consists of a lecture and a seminar. The lecture gives an overview of the theoretical foundations and current issues in animal ecology. Focus will be on biodiversity and ecosystem functions, multi-trophic interactions and food nets, evolutionary ecology, chemical ecology, tropical ecology, agricultural ecology, and global change. In the seminar, recent scientific publications within the topics mentioned above will be presented and discussed.

### Intended learning outcomes
The students will acquire an advanced knowledge of ecological theories and current research issues in the field of animal ecology. They will be able to interpret scientific publications and apply the acquired knowledge to the solution of current environmental risks.

### Courses
(type, number of weekly contact hours, language — if other than German)

V (2) + S (1)
Module taught in: German and/or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)
Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)
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Module title: Animal Ecology and Tropical Biology 2
Abbreviation: 07-MS1TÖ2-152-m01

Module coordinator: holder of the Chair of Animal Ecology and Tropical Biology

Module offered by: Faculty of Biology

ECTS: 10
Method of grading: numerical grade
Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
This module provides the fundamentals of the biology of tropical habitats and tropical communities. A special focus is on the global significance of tropical systems (ecosystem goods and ecosystem services), but the biological features of these highly diverse biomes are also highlighted.

Intended learning outcomes:
The students will acquire deep knowledge of ecological theories and up-to-date research issues in the field of animal ecology of the tropics. They will be qualified to interpret scientific work and apply the knowledge they have acquired to the solution of current environmental risks.

Courses:
(type, number of weekly contact hours, language — if other than German)
V (2) + S (1)

Module taught in: English

Method of assessment:
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)
Language of assessment: German and/or English

Allocation of places:
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Additional information:
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Referred to in LPO I: (examination regulations for teaching-degree programmes)
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Module title | Abbreviation
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Animal Ecology F1 | 07-MS1TÖF1-152-m01

Module coordinator | Module offered by
holder of the Chair of Animal Ecology and Tropical Biology | Faculty of Biology

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Contents

This module consists of several exercises and a seminar series over the course of the entire semester. The exercises can be chosen from the following electives: 1. Wild and honeybee ecology (over the course of the semester): fundamentals and techniques of beekeeping, resource utilisation, behaviour experiments, pollinator diversity and plant-pollinator-interactions. 2. Ecology and taxonomy of insects (block, 2 weeks): observation and recording in the habitat, identification and characteristics of different arthropod groups, field experiments. 3. Ecological modelling (block, 2 weeks): current methods of ecological processes modelling, simulation models, the students’ own modelling project on current issues in ecology. 4. Agroecology (block, 1 week): insect communities in agroecosystems, biological pest control in landscape context, evaluation of agri-environment schemes. 5. Forest ecology (block, 1 week): arthropod communities in forest ecosystems, methods of detection, influence of management on diversity patterns and functional groups. 6. Tropical ecology (block): small projects ecological or nature conservation-related issues to be implemented in a tropical ecosystem in East Africa. In the seminar, recent scientific publications on the topics covered in the modules listed above will be presented and discussed.

Intended learning outcomes

Students will have expanded their knowledge on ecological theories and current research issues in animal ecology. They will be able to design, perform, statistically analyse and interpret scientific research. They will be familiar with animal ecological methods and possible sources of error in data interpretation. They will have deepened their knowledge of the biology and ecology of important functional taxa of arthropods. Students will have acquired the knowledge and skills necessary to perform scientific activities in the context of an F2 practical course or a Master’s thesis.

Courses (type, number of weekly contact hours, language — if other than German)
P (14) + S (1)
Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Animal Ecology and Tropical Biology F2

**Abbreviation**: 07-MS1TÖF2-152-m01

**Module coordinator**

holder of the Chair of Animal Ecology and Tropical Biology

**Module offered by**

Faculty of Biology

**ECTS**: 15

**Method of grading**: Only after successfully completed module(s)

**Duration**: 1 semester

**Module level**: Graduate

**Other prerequisites**: --

**Contents**

In the F2 practical course, students will explore a scientific question as independently as possible. They will develop hypotheses, prepare a work schedule, collect data, perform experiments in the field, greenhouse or laboratory and will statistically analyse data. Students will document the results of their work in a log similar to a short scientific paper, including an introduction, material and methods, findings and a discussion of these. Students will also be required to present their findings during a wrap-up seminar. The various research groups at the Chair of Animal Ecology and Tropical Biology offer a wide variety of opportunities for students to complete an F2 practical course in Germany, another country in Europe or in the tropics. F2 practical courses may be completed in the context of an ongoing research project of the Institute or in cooperation with other institutions. For more detailed information on the F2 practical course as well as current topics or appointments for consultations, please refer to WuCampus, check out the notice board of the Chair or contact the research groups directly.

**Intended learning outcomes**

Students have gained knowledge on experimental setups and methods used in the fields of animal ecology and tropical ecology. They are qualified to design scientific research and are able to collect data and interpret them statistically. They have developed knowledge and skills that allow them to set up a scientific project for their Master's thesis.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (29) + S (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
--- | ---
Animal Communication | 07-MS1K-152-m01

| Module coordinator | Module offered by |
| | |
| holder of the Chair of Behavioral Physiology and Sociobiology | Faculty of Biology |

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**Contents**

The lectures deal with physiological and neurobiological principles of the different communication channels used by animals, but also highlight adaptive values and evolutionary aspects of animal signalling. In a follow-up seminar session, students will deepen their knowledge by presenting and discussing current papers related to the topic of the lecture.

**Intended learning outcomes**

Students understand the value of an integrative approach when looking at complex issues in biology. They have learned to connect findings from different research areas, such as physiology, neurobiology, behaviour and ecological conditions, in order to gain a more complete picture of a topic. In addition, students have learned to present and discuss current scientific publications within a broader theoretical framework.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
--- | ---
Experimental Sociobiology | 07-MS1ES-152-m01

Module coordinator | Module offered by
holder of the Chair of Behavioral Physiology and Sociobiology | Faculty of Biology

ECTS | Method of grading | Only after succ. compl. of module(s)
10 | numerical grade | --

Duration | Module level | Other prerequisites
1 semester | graduate | --

Contents
The lecture covers the diversity and the development of social behaviour as well as the behavioural physiology and mechanisms of neurobiology that are the basis of the organisation of social groups. A special focus is on current research in the Faculty. With the help of selected publications, the seminar will discuss and explore in more detail the topics covered in the lecture.

Intended learning outcomes
Students understand the value of an integrative approach when looking at complex correlations in behavioural biology. Students are able to recognise and interpret relationships between various aspects of sociobiology. They are able to formulate scientific questions in the context of sociobiology and are able to discuss cutting edge literature in depth.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + S (1)
Module taught in: English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)
Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Module title | Abbreviation
---|---
Behavioural Physiology and Sociobiology F1 | 07-MS1VF1-152-m01

Module coordinator

holder of the Chair of Behavioral Physiology and Sociobiology

Module offered by

Faculty of Biology

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Contents

Students will be integrated into one of the research groups at the Chair and will independently work on one of the current topics in the field of behavioural physiology and sociobiology. They will gain an insight into the latest physiological, neurobiological and behavioural methods. The results obtained will be graphically and statistically analysed, summarised in a scientific report and presented in a talk. Please contact the research groups at the Chair for available topics and opportunities.

Intended learning outcomes

The students are able to independently perform scientific experiments in the field of behavioural physiology and sociobiology. In addition, they are able to process and document the results obtained and to present them to a scientific audience.

Courses (type, number of weekly contact hours, language — if other than German)

P (14) + S (1)

Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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# Subdivided Module Catalogue for the Subject MINT Teacher Education PLUS, Elite Network Bavaria (ENB)

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## Contents

Students will be integrated into one of the research groups at the Chair and will independently work on one of the current topics in the field of behavioural physiology and sociobiology. They will learn to plan experimental series and to apply the latest physiological, neurobiological and behavioural methods. The results obtained will be graphically and statistically analysed, summarised in a scientific report and presented in a talk. Please contact the research groups at the Chair for available topics and opportunities.

## Intended learning outcomes

The students are able to independently perform scientific experiments in the field of behavioural physiology and sociobiology. In addition, they have learned to interpret the results obtained, taking into account current literature, and to place them in the context of other research in the field.

## Courses

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Module taught in: German and/or English

## Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

## Allocation of places

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## Additional information

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## Referred to in LPO I

(examination regulations for teaching-degree programmes)

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**Contents**

Molecular biology of the eukaryotic and prokaryotic cell. The lecture is a joint activity of the Chairs of Cell- and Developmental Biology, Microbiology, Biophysics and Bioinformatics and deals with concepts of modern molecular biology from the point of view of these different disciplines. Participants are recommended to read the textbook "Essential Cell Biology". The section on cell biology (app. a quarter of the lecture) mainly discusses the eukaryotic cell and intends to elucidate the vast diversity in structure and function of molecules, organelles and cells in addition to fundamental principles of modern molecular cell biology. The bioinformatics section (app. a quarter of the lecture) contains a large amount of examples for applications which allow the investigation of the molecular biology of a cell with bioinformatic tools. We closely adhere to the contents of the book "Essential Cell Biology" and present many clear and useful examples for the application of our tools when working on the topics of the other three Chairs. Our vision: bioinformatics essentially is molecular biology based on computing technology (time consuming "wet" experiments can be planned more easily and thus bioinformatics saves precious time). The microbiological section (app. a quarter of the lecture) deals with fundamental molecular aspects of prokaryotic cells. Key aspects include the organisation of the bacterial genome, the transcription and translation machinery, mechanisms of regulation of gene expression, transport of small molecules and macromolecules, cell division and differentiation, bacterial motility and chemotaxis, signal transduction and bacterial communication mechanisms. Recommended reading: (a) Allgemeine Mikrobiologie (Fuchs) and (b) Biology of Microorganisms (Brock).

**Intended learning outcomes**

Master level knowledge about the molecular biology of the eukaryotic and prokaryotic cell.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
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Cell and Developmental Biology Master 1 | 07-MS2ZE1-152-m01

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Contents

The module consists of the lecture *Zellpathologie* (*Cytopathology*) and the seminar *Zellbiologie-Milesteine und Perspektiven* (*Milestones and Perspectives of Cell Biology*). The lecture describes pathological states of the cell and unravels their biological causes and consequences, such as infection, apoptosis, senescence, metabolic disorders and cancer. In the seminar *Milestones and Perspectives of Cell Biology*, classic ground-breaking publications in the field of cell biology are discussed from an unusual point of view.

Intended learning outcomes

Students possess a knowledge of the theoretical principles underlying cell pathology and are able to put this into the broader context of cell biology research.

Courses (type, number of weekly contact hours, language — if other than German)

| V (1) + S (2) |
Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

Allocation of places

Additional information

Referred to in LPO I (examination regulations for teaching-degree programmes)
### Module title
Cell and Developmental Biology Master 2

### Abbreviation
07-MS2ZE2-152-m01

### Module coordinator
holder of the Chair of Cell Biology and Developmental Biology

### Module offered by
Faculty of Biology

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### ECTS
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### Method of grading
numerical grade

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### Contents
The module consists of the lecture *Signale und Differenzierung* (Signals and Differentiation) and the seminar *Entwicklungsbio- logie - Meilensteine und Perspektiven* (Milestones and Perspectives of Developmental Biology). The lecture *Signals and Differentiation* does not attempt to impart pure textbook knowledge. Instead, historically important as well as particularly interesting and important trend-setting topics in developmental biology are presented. The topics range from classical developmental subjects such as tissue regeneration and morphogenetic cell migration to molecular stem cell biology, epigenetic plasticity, origins of multicellularity and development within changing environments. In the seminar *Milestones and Perspectives of Developmental Biology*, classic ground-breaking publications in the field of developmental biology are discussed from an unusual point of view.

### Intended learning outcomes
Participants possess a knowledge of the theoretical and molecular biological principles underlying developmental biology and are able to put this into the broader context of cell and developmental biology research.

### Courses (type, number of weekly contact hours, language — if other than German)

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Module taught in: English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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## Module title

**Cell and Developmental Biology F1**

### Abbreviation

07-MS2ZEF1-152-m01

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### Contents

This 5 week full-time practical course provides an introduction to modern cell and developmental biology-related methods with a focus on bio-imaging techniques. A broad variety of model organisms is covered and the participants are encouraged to independently design and perform their own experiments. Participants use their acquired technological skills to analyse important basic biological processes. Large parts of this practical course are devoted to small projects, which should provide sustained insights into current research activities of the Chair. Interactions with Master's students, doctoral researchers and post-docs prepare participants for a working in a team-based environment.

### Intended learning outcomes

The participants are able to approach complex scientific questions in the fields of cell and developmental biology and to independently implement acquired methodological tools to answer these questions. They are able to perform and document cell and developmental biology-related experiments, adhering to a generally accepted code of scientific practice.

### Courses (type, number of weekly contact hours, language — if other than German)

**P (14) + S (1)**

Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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<tr>
<td>Well-defined aspects of scientific projects are addressed with independently designed experiments in the context of current research projects in the field of cell and developmental biology. The techniques applied are evaluated on the basis of the results obtained and modified where necessary. The results of all experiments as well as the impact on the research project are presented and discussed in a progress report seminar within the research group.</td>
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<td>The participants are able to independently carry out scientific experiments in the fields of cell and developmental biology and to modify them according to the outcome. They are able to independently approach current scientific topics and to perform, interpret and document experiments, adhering to accepted rules of scientific practice.</td>
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**Contents**

Fundamentals of molecular microbiology and infection biology, mechanisms of adherence and invasion, bacterial pathogenicity factors, regulation of virulence, mechanisms of host defence and pathogen interference, current methods in infection biology.

**Intended learning outcomes**

The students are able to understand fundamental theories of molecular microbiology and infection biology, emergence of infectious diseases.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (2) + S (1)

Module taught in: German and/or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

**Allocation of places**

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**Contents**

Fundamental principles of the mode of action of microbial pathogenicity factors will be presented using selected prokaryotic and eukaryotic pathogens as model organisms. In addition, current research methods in infection biology will be presented.

**Intended learning outcomes**

Students have gained fundamental knowledge in infection biology and pathogenicity research and the mechanisms behind infectious diseases.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (1)

Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title: Microbiology F1
Abbreviation: 07-MS2MF1-152-m01

Module coordinator: holder of the Chair of Microbiology
Module offered by: Faculty of Biology

ECTS: 10
Method of grading: numerical grade
Only after succ. compl. of module(s): --

Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
Under guidance, participants will work on a current research project dealing with microbial pathogens and their interactions with the host. Participants will employ a variety of state-of-the-art methods within the fields of molecular biology, microbiology, cell biology, and immunology as well as data analysis and literature search techniques. Results will be documented and discussed in a seminar paper or an oral presentation.

Intended learning outcomes:
Participants will acquire the skills to experimentally address scientific questions in molecular biology and infection biology, properly document experimental results and adhere to the standards of good scientific practice.

Courses (type, number of weekly contact hours, language — if other than German):
P (14) + S (1)
Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus):
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Language of assessment: German and/or English

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
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**Module title**
Microbiology F2

**Abbreviation**
07-MS2MF2-152-m01

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**Contents**

Participants will independently work on a current research project dealing with microbiology and infection biology. They will apply advanced experimental techniques in microbiology, cell biology and molecular biology according to the project requirements. Progress of the research project will be reported in a seminar paper, a research paper or an oral presentation.

**Intended learning outcomes**

The participants will acquire the skills to independently perform basic research on microbiology and infection biology according to the standards of good scientific practice and to properly document, interpret and present experimental results.

**Courses**

(type, number of weekly contact hours, language — if other than German)

P (29) + S (1)

Module taught in: German and/or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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Module title: Biophysics and Molecular Biotechnology  
Abbreviation: 07-MS2BT-152-m01

Module coordinator: holder of the Chair of Biotechnology and Biophysics  
Module offered by: Faculty of Biology

ECTS: 10  
Method of grading: numerical grade  
Only after succ. compl. of module(s): --

Duration: 1 semester  
Module level: graduate  
Other prerequisites: --

Contents
This lecture provides a broad overview of biophysical techniques and their applications. The first part of the lecture discusses fundamental aspects of thermodynamics, kinetics and molecular interactions. The course then moves on to discuss biophysical methods that facilitate the investigation of individual cells down to the level of single molecules. Focus is on electromanipulation and dielectric spectroscopy of cells, biomembranes, electrophysiology, ion channels, protein folding, single-molecule fluorescence methods and high-resolution as well as dynamic microscopy.

Intended learning outcomes
Students will have acquired a knowledge of fundamental biophysical methods and their applications that will enable them to independently review relevant literature. In addition, they will have become acquainted with - or, where necessary, will be able to independently acquaint themselves with - biophysical mechanisms.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + S (1)  
Module taught in: English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Language of assessment: German and/or English

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**Contents**

The module imparts theoretical and methodological knowledge of plant membrane transport, structural biology and biochemistry which is illustrated with specific examples from current research. Depending on the number of participants and their interests, practical demonstrations of methods that are currently used give students an opportunity to experience the practical aspects of biophysical and biochemical research.

**Intended learning outcomes**

Students are able to use methods dealing with soluble proteins or membrane proteins in the fields of biophysics, structural biology and biochemistry. They are able to interpret the data and to discuss the results within the context of current knowledge.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (1)

Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

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### Contents

Advances and current results of bioinformatics are explained and discussed, this includes results from genome and sequence analysis, protein domains and protein families, large-scale data analysis (e.g. net generation sequences, proteomics data), analysis of different functional RNAs (e.g. miRNAs, IncRNAs).

### Intended learning outcomes

Understand recent results in bioinformatics. Discuss their implications. Have an advanced (Master) level knowledge of typical technologies and research questions in bioinformatics.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + S (1)

Module taught in: German and/or English

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Language of assessment: German and/or English

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### Module title

**Biophysics and Molecular Biotechnology F1**

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### Module coordinator

holder of the Chair of Biotechnology and Biophysics

### Module offered by

Faculty of Biology

### ECTS  Method of grading  Only after succ. compl. of module(s)

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### Contents

This practical course provides students with an insight into different biotechnological and biophysical topics and methods. Under expert guidance, students will perform selected experiments on the following topics: cellular and molecular biotechnology, nano and microsystems biotechnology, biomaterials and biosensors, high-resolution fluorescence microscopy, fluorescence spectroscopy, analysis and electromanipulation of cells.

### Intended learning outcomes

Students will have acquired a knowledge of fundamental biotechnological and biophysical methods and their applications that will enable them to independently review relevant literature. In addition, they will have become acquainted with - or, where necessary, will be able to independently acquaint themselves with - biophysical mechanisms. Students will have acquired practical experience performing experiments, using a variety of scientific tools. In the seminar, students will have acquired detailed theoretical knowledge on these experiments and will have delivered a short presentation (15 minutes) on one of the experiments they performed.

### Courses (type, number of weekly contact hours, language — if other than German)

P (14) + S (1)

Module taught in: German and/or English

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<td>1 semester</td>
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**Contents**

This practical course provides students with an insight into different biotechnological and biophysical topics and is close to laboratory research. Under expert guidance, students will perform selected experiments on one of the following topics: cellular and molecular biotechnology, nano and microsystems biotechnology, biomaterials and biosensors, high-resolution fluorescence microscopy, fluorescence spectroscopy, analysis and electromanipulation of cells. Performing experiments under expert guidance, students will become acquainted with techniques and instruments. Over the duration of the course, students will then be required to work increasingly independently on current research topics. Work on current research topics will spark the students' interest in topics and will help them select a topic for their Master's thesis.

**Intended learning outcomes**

Students will become acquainted with modern biophysical methods and their applications in biotechnology. They will be able to independently work on scientific problems, to independently study relevant literature and to develop a quantitative understanding of biophysical mechanisms. In the seminar, students will acquire further theoretical knowledge on experiments and will give short presentations on experiments performed.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (29) + S (1)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)
Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
--- | ---
Current Methods in Biology | 07-MS31-152-m01

Module coordinator | Module offered by
holder of the Chair of Plant Physiology and Biophysics | Faculty of Biology

ECTS | Method of grading | Only after succ. compl. of module(s)
10 | numerical grade | --

Duration | Module level | Other prerequisites
1 semester | graduate | --

Contents
This lecture series imparts the theoretical background of fundamental and up-to-date molecular biological methods in plant sciences. Special emphasis is placed on analytical tools, large-scale data analysis and their application.

Intended learning outcomes
At the end of the lecture series, students will (I) be able to qualitatively evaluate results acquired with analytical and molecular biological methods and to integrate them into the context of the current scientific knowledge in this field (II) have gained an overview of the advantages/disadvantages of analytical and molecular biological approaches (III) be able to apply the knowledge they have acquired to design their own experimental strategies for addressing a specific research question.

Courses
(type, number of weekly contact hours, language — if other than German)

V (3)
Module taught in: German and/or English

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

Allocation of places
--

Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Module title

| Plant Ecology | 07-MS31POEK-152-m01 |

### Module coordinator

| holder of the Chair of Ecophysiology and Vegetation Ecology |

### Module offered by

| Faculty of Biology |

### ECTS

| 10 |

### Method of grading

| numerical grade |

### Only after succ. compl. of module(s)

| -- |

### Duration

| 1 semester |

### Module level

| graduate |

### Other prerequisites

| -- |

## Contents

The lecture will deal with the ecological and environmental constraints under which plants grow and develop (biogeography, biodiversity) and with the interactions of plants with abiotic and biotic environmental factors (e.g. plant-insect, plant-fungus interactions). The evolutionary adaptations on the physiological and organismic level will be emphasised in particular (stress and defence reactions, carnivory, plant protection). Corresponding experimental approaches will be illustrated. Based on selected examples from current research, the seminar will address the topics covered in the lecture in more detail. It will be complemented by topic-related guided tours in the Botanical Garden of the University of Würzburg.

## Intended learning outcomes

Participants are able to identify and interpret ecological and ecophysiological interrelations and to discuss them in the context of the current state of knowledge in these fields.

## Courses

| type, number of weekly contact hours, language — if other than German |

### V (2) + S (1)

Module taught in: German and/or English

## Method of assessment

| type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus |

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

## Allocation of places

| -- |

## Additional information

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## Referred to in LPO I

(examination regulations for teaching-degree programmes)

| -- |
### Contents

This lecture addresses topics of pathogen recognition and signal transduction in plants, molecular and organismic defence and the pharmaceutical relevance of plant-derived bioactive compounds. Plant immunobiology: interactions between plants and pathogens comprise evolutionary dynamic and complex systems. Different strategies of the pathogens - bacteria, fungi and viruses - as well as defence mechanisms of the host plants will be discussed. The molecular mechanisms of pathogen recognition, signal transduction, regulation of gene expression and activation of local and systemic defence responses are in the focus of this lecture. Differences and similarities between plant and human immune systems will be pointed out. Understanding plant-pathogen-interactions and molecular mechanisms determining susceptibility and defence is fundamental for the development of strategies in plant protection. Evolution, function and pharmaceutical relevance of plant secondary metabolites: Secondary metabolites are part of effective plant defence strategies against microorganisms and herbivores and are often essential for survival. The evolution of secondary metabolism will be discussed and general as well as specific defence strategies will be explained. Pharmacological mechanisms of action and molecular targets of important classes of plant bioactive compounds will be presented. A high proportion of currently used drugs have been developed from plant secondary metabolites that have been used as lead structures to generate potent drugs with improved pharmaceutical properties. Examples of therapies with very potent plant pharmaceuticals (evidence-based medicine) as well as possibilities and limitations of phytotherapy (traditional medicine) will be discussed.

### Intended learning outcomes

Students are able to understand the interaction between plants and the environment on a molecular level and to discuss the topic in the context of the scientific state of the art.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + S (1)

Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English
Module title: Systems Biology

Abbreviation: 07-MS3S-152-m01

Module coordinator: holder of the Chair of Bioinformatics

Module offered by: Faculty of Biology

ECTS: 10

Method of grading: numerical grade

Only after succ. compl. of module(s)

Duration: 1 semester

Module level: graduate

Other prerequisites: --

Contents:
Advances and current results of computational systems biology are explained and discussed, this includes results from functional genomics, dynamics of the transcriptome, of metabolism and metabolic networks as well as regulatory networks.

Intended learning outcomes:
Understand recent results in systems biology. Discuss their implications. Have an advanced (Master) level knowledge of typical technologies and research questions of systems biology.

Courses:
V (2) + S (1)

Module taught in: German and/or English

Method of assessment:
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
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**Module coordinator**  
holder of the Chair of Bioinformatics

**Module offered by**  
Faculty of Biology

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**Duration**  
1 semester

**Module level**  
graduate

**Other prerequisites**  
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### Contents

Detailed insight into methods in bioinformatics; depending on the topic selected, fields covered include: genomics (sequence-, domain analysis and annotation), omics data analysis (NGS, transcriptomics, metabolomics, proteomics), topological and structural analysis of biological interactions including statistical methods, phylogenetic analysis, protein structure analysis. Results are documented in the form of a presentation, a publication or a term paper.

### Intended learning outcomes

Students have gained knowledge on experimental setups and methods used in the field of bioinformatics. They are able to design experiments, collect data and interpret them statistically, adhering to the principles of good scientific practice.

### Courses

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**Method of assessment**  
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen:  
a) written examination (30 to 60 minutes, including multiple choice questions)  
b) log (15 to 30 pages)  
c) oral examination of one candidate each (30 to 60 minutes)  
d) oral examination in groups of up to 3 candidates (30 to 60 minutes)  
e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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### Module title
Bioinformatics F2

### Abbreviation
07-MS2BIF2-152-m01

### Module coordinator
holder of the Chair of Bioinformatics

### Module offered by
Faculty of Biology

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### Contents
Advanced insight into methods in bioinformatics; depending on the topic selected, fields covered include: genomics (sequence-, domain analysis and annotation), omics data analysis (NGS, transcriptomics, metabolomics, proteomics), topological and structural analysis of biological interactions including statistical methods, phylogenetic analysis, protein structure analysis. The techniques applied are evaluated on the basis of the results obtained and are modified where necessary. Results are documented in the form of a presentation, a publication or a term paper.

### Intended learning outcomes
Proficiency in one or more methods in bioinformatics that allows students to independently perform and organise a scientific project in the field of bioinformatics and to document the results obtained. Students are able to design a research project and are prepared for working on a scientific question for their thesis.

### Courses
(type, number of weekly contact hours, language — if other than German)

P (29) + S (1)

Module taught in: German and/or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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**Contents**

Practical course, summer school or workshop on specific topics in biology (duration: 4-6 weeks).

**Intended learning outcomes**

Proficiency in specific methods and lab techniques from selected fields of biology. Ability to apply these methods and techniques later on in a research project.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (15)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Contents**

The module provides an in-depth insight into molecular biological strategies and methods applied in plant physiology. The students will be integrated into research projects on current topics in molecular plant physiology.

**Intended learning outcomes**

The students have knowledge about basic molecular biological strategies and methods focusing on plant physiology. They are able to perform and organise their scientific laboratory work independently and document the results obtained.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (14) + S (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Contents**

The students perform their research work within the context of a current research project in molecular plant physiology in a largely independent manner under supervision of a principal investigator.

**Intended learning outcomes**

Students are able to work on a scientific question, to design an experimental setup as well as to interpret, document and present their results.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (29) + S (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module title: Biochemistry and Structural Biology F1

Abbreviation: 07-MS3BSBF1-152-m01

Module coordinator: holder of the Chair of Plant Physiology and Biophysics

Module offered by: Faculty of Biology

ECTS: 10

Method of grading: numerical grade

Duration: 1 semester

Module level: graduate

Other prerequisites: --

Contents:
The module provides an in-depth insight into strategies and methods in protein biochemistry and structural biology. The students will be integrated into research projects on current topics in biochemistry and structural biology.

Intended learning outcomes:
The students have knowledge about general strategies and methods of protein biochemistry and structural biology with a focus on membrane proteins. They are able to perform and organise their scientific laboratory work independently and document the results obtained.

Courses (type, number of weekly contact hours, language — if other than German):
P (14) + S (1)

Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus):
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

Allocation of places: --

Additional information: --

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**Module coordinator**
holder of the Chair of Plant Physiology and Biophysics

**Module offered by**
Faculty of Biology

**ECTS**
15

**Method of grading**
Only after succ. compl. of module(s)

**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
--

### Contents
The students perform their research work within the context of a current research project on biochemistry and structural biology in a largely independent manner under supervision of a principal investigator.

### Intended learning outcomes
The students are able to independently perform and organise their scientific laboratory work in the fields of biochemistry and structural biology and to document the results obtained. They are able to design a research project and are prepared for working on a scientific question for their thesis.

### Courses
(type, number of weekly contact hours, language — if other than German)

P (29) + S (1)

Module taught in: German and/or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)
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### Module title
Biophysics of Plant Membrane Proteins F1

### Abbreviation
07-MS3BPF1-152-m01

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### Contents
The module provides an in-depth insight into biophysical strategies and methods which are used for the functional characterisation of plant membrane proteins. The students will be integrated into research projects on current topics in molecular plant membrane biology.

### Intended learning outcomes
The students have knowledge of general biophysical strategies and methods with a focus on plant membrane proteins, they are able to independently work on related scientific issues and to document the results obtained.

### Courses (type, number of weekly contact hours, language — if other than German)
P (14) + S (1)

Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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**Contents**

The students perform their research work within the context of a current research project on the biophysics of plant membrane proteins in a largely independent manner under supervision of a principal investigator.

**Intended learning outcomes**

The students are able to address scientific issues in biophysics, using appropriate biophysical methods. They are able to independently design the appropriate experiments as well as to analyse, document, present and discuss the results.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (29) + S (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Subdivided Module Catalogue for the Subject
**MINT Teacher Education PLUS, Elite Network Bavaria (ENB)**, 120 ECTS credits

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<th>Module title</th>
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<td>Plant Signalling F1</td>
<td>07-MS3SPF1-152-m01</td>
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### Contents

Molecular mechanisms of plant signal transduction and regulation of gene expression will be investigated in the context of plant-pathogen interaction, plant responses to abiotic stress, lipid signalling and plant hormone signalling. Specific molecular biology methods which are suitable to address these topics will be applied. In addition, students will gain experience in designing appropriate experimental approaches as well as in the documentation and presentation of results. Students will work on a current research project and learn to independently plan and perform the experiments. More information is available on request or can be found at [http://www.p-bio.biozentrum.uni-wuerzburg.de/](http://www.p-bio.biozentrum.uni-wuerzburg.de/).

### Intended learning outcomes

Students will be trained to apply specific methods in the field of molecular biology, to address scientific questions, to document experimental procedures and results and to interpret experimental data.

### Courses (type, number of weekly contact hours, language — if other than German)

P (14) + S (1)

Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places

--

### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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## Module title

**Plant Signalling F2**

**Abbreviation**

07-MS3SPF2-152-m01

### Module coordinator

holder of the Chair of Plant Physiology and Biophysics

### Module offered by

Faculty of Biology

### ECTS

15

### Method of grading

Only after succ. compl. of module(s)

### (not) successfully completed

--

### Duration

1 semester

### Module level

graduate

### Other prerequisites

--

### Contents

Students will independently work on aspects of current research projects in the area of plant signal transduction and stress responses. Results will be discussed in the context of recent publications. The molecular biology and bioanalytical methods which are used will be evaluated and optimised. The aim and progress of the project will be presented in a seminar. More information is available on request or can be found at [http://www.pbio.biozentrum.uni-wuerzburg.de/](http://www.pbio.biozentrum.uni-wuerzburg.de/).

### Intended learning outcomes

Students are able to independently perform scientific experiments and to use specific techniques in the field of molecular biology and bioanalytics to address scientific questions in the field of plant signal transduction. Students are able to independently work according to the rules of best practice.

### Courses

**P (29) + S (1)**

Module taught in: German and/or English

### Method of assessment

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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**Contents**

All organisms are able to reprogram their metabolism in response to various endogenous or exogenous perturbations. Reprogramming of metabolism is often correlated to phenotypic changes e.g. in disease development, physiology or behaviour. At the Chair of Pharmaceutical Biology, we apply metabolomics for gene function- or stress response analysis. Students can choose a topic from the variety of ongoing projects. Depending on the scientific question addressed by the research team at the Chair, the methodological approach involves techniques in the field of metabolomics/bioanalytics and/or molecular biology. In this module, students will be trained to use quantitative metabolite analysis methods (chromatography, mass spectrometry) and apply advanced molecular biology techniques. Depending on the project, different model organisms are studied. Prior knowledge in metabolite analysis or mass spectrometry is not required. Current scientific questions in the life sciences form the basis to impart scientific concepts and to train students in the laboratory. The module involves the experimental design, realisation and critical evaluation of scientific experiments as well as the documentation and presentation of the progress. More information is available on request or can be found at [http://www.pbio.biocentrum.uni-wuerzburg.de/](http://www.pbio.biocentrum.uni-wuerzburg.de/).

**Intended learning outcomes**

Students will be trained in using specific molecular biology methods and/or metabolomics approaches to address scientific questions, in the documentation of experimental procedures and results, and in the interpretation of data.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (14) + S (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title
Pharmaceutical Biology and Metabolomics F2

### Abbreviation
07-MS3PBMF2-152-m01

### Module coordinator
holder of the Chair of Pharmaceutical Biology

### Module offered by
Faculty of Biology

### ECTS
15

### Method of grading
(only after successfully completed module(s)

### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

### Contents
Students will be involved in current research projects in pharmaceutical biology or in collaborative research projects that focus on the regulation of metabolism and analysis of metabolic pathways (e.g. in the context of reactions towards biotic or abiotic stress, functional and phenotypic analysis of mutants, or drug metabolism). Aspects of the scientific question will be independently addressed by the students. Molecular biology methods and/or metabolomic approaches will be optimised for and adapted to the specific problem. Experimental results and progress in the understanding of biological problems will be documented in the form of a log and presented in a seminar. More information is available on request or can be found at http://www.pbio.biozentrum.uni-wuerzburg.de/.

### Intended learning outcomes
The participants are able to independently carry out scientific experiments and to modify them according to the outcome. They are able to independently approach scientific topics in pharmaceutical biology and to perform, interpret and document experiments, adhering to accepted rules of scientific practice. They are able to apply specific techniques required to answer scientific questions.

### Courses
(P (29) + S (1))
Module taught in: German and/or English

### Method of assessment
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)
Language of assessment: German and/or English

### Allocation of places
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### Additional information
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**Contents**

Under the guidance of an experienced scientist, students will work on a current research topic from the field of ecology/ecophysiology. Particular emphasis will be placed on the physiological bases of the interactions between plants and abiotic and biotic environmental factors (e.g., water relations, stress, biogeography). Working concepts and complex experiments will be designed, and the results will be documented and presented in the form of a presentation, a publication or a log. The participants will be involved in ongoing projects and will deepen their knowledge on applying special methods, in ecophysiology in particular but also in chemical analysis.

**Intended learning outcomes**

The participants are able to perform scientific experiments in the field of physiological plant ecology and to apply appropriate methods. They are also able to address and document questions in the field of ecology/ecophysiology, adhering to the rules of good scientific practice.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (14) + S (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Contents**

Students will work on projects taken from ongoing research in the supervisors' labs in the field of plant ecology and ecophysiology (e.g. plant-insect-, plant-fungus interactions; biogeography; water relations). They will do this work to a large extent on their own responsibility by performing advanced experiments, their documentation and evaluation. Based on the results obtained, the ecophysiological and analytical methods applied (e.g. measurement of transpiration, fluorescence microscopy, chlorophyll-fluorometry) will be critically assessed, and, where necessary, modified. The progress of the experiments and their contribution to more general projects will be documented and presented in the form of presentations, publications or logs.

**Intended learning outcomes**

Students have gained knowledge on experimental setups and methods used in the field of plant ecophysiology. They are able to design scientific research, to collect data and to interpret them statistically, adhering to the principles of good scientific practice.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (29) + S (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

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**Contents**

Under the guidance of an experienced scientist, students will work on a current research topic from the field of molecular and chemical plant ecology. Particular emphasis will be placed on the molecular and chemical bases of the interactions between plants and abiotic and biotic environmental factors (e. g. cuticular barrier properties, plant-insect, and plant-fungus interactions). Working concepts and complex experiments will be designed, and the results will be documented and presented in the form of presentations, publications or logs. The participants will be involved in ongoing projects and will deepen their knowledge on applying special methods, in molecular biology in particular but also in chemical analysis.

**Intended learning outcomes**

The participants are able to perform scientific experiments in the field of molecular and chemical plant ecology and to apply appropriate methods. They are also able to address and document questions in the field of molecular biology/chemical ecology, adhering to the rules of good scientific practice.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (14) + S (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Contents**

Students will work on projects taken from ongoing research in the supervisors' labs from the field of molecular and chemical plant ecology (e.g. cuticular barrier properties, plant-insect, and plant-fungus interactions). They will do this work to a large extent on their own responsibility by performing advanced experiments, their documentation and evaluation. Based on the results obtained, the analytical, molecular biological and/or microbiological methods applied (e.g. PCR, cloning strategies, chromatography, mass spectrometry) will be critically assessed and, where necessary, modified. The progress of the experiments and their contribution to more general projects will be documented and presented in the form of presentations, publications or logs.

**Intended learning outcomes**

The participants are able to independently perform scientific experiments in the field of molecular and chemical plant ecology and to modify them according to the outcome. They are able to independently address, document and interpret questions in the field of molecular/chemical plant ecology, adhering to the rules of good scientific practice. Students are also able to apply specific techniques required to answer scientific questions.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (29) + S (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Module coordinator**
holder of the Chair of Bioinformatics

**Module offered by**
Faculty of Biology

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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
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### Contents
The practical course will provide students with advanced insights into a field of systems biology and will, in particular, make students proficient in a dynamical method in systems biology (areas that may be selected include protein structure analysis and protein folding, genome analysis and evolution; dynamic network analysis, the dynamics of protein-protein interactions, modelling cellular regulation; modelling metabolism, statistical modelling).

### Intended learning outcomes
Students have gained knowledge on experimental setups and methods used in the field of systems biology. They are able to design scientific research, to collect data and to interpret them statistically, adhering to the principles of good scientific practice.

### Courses
(type, number of weekly contact hours, language — if other than German)

- **P (14) + S (1)**
  Module taught in: German and/or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

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Module title: Systems Biology F2 | Abbreviation: 07-MFS3SYF2-152-m01

Module coordinator: holder of the Chair of Bioinformatics
Module offered by: Faculty of Biology

ECTS: 15 | Method of grading: Only after succ. compl. of module(s) | (not) successfully completed: --

Duration: 1 semester | Module level: graduate | Other prerequisites: --

Contents:
The practical course will provide students with advanced insights into a field of systems biology and will, in particular, make students proficient in a dynamical method in systems biology (areas that may be selected include protein structure analysis and protein folding, genome analysis and evolution; dynamic network analysis, the dynamics of protein-protein interactions, modelling cellular regulation; modelling metabolism, statistical modelling). The techniques applied are evaluated on the basis of the results obtained and are modified where necessary. Results are documented in the form of a presentation, a publication or a term paper.

Intended learning outcomes:
Proficiency in one or more methods in systems biology that allows students to independently perform and organise a scientific project in the field of bioinformatics and to document the results obtained. Students are able to design a research project and are prepared for working on a scientific question for their thesis.

Courses (type, number of weekly contact hours, language — if other than German):
P (29) + S (1)
Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus):
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Language of assessment: German and/or English

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
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### Methods in Life Sciences B

**Abbreviation**

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**Module coordinator**

- degree programme coordinator Biologie (Biology)

**Module offered by**

- Faculty of Biology

**ECTS**

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**Duration**

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### Contents

Versioned molecular techniques, lipid research methods, microscopic methods, immunohistochemistry, mouse models and gene-knockout approaches, protein and molecular biology techniques, PCR, advanced protein biochemistry, methods in bioinformatics and computational biology.

### Intended learning outcomes

Students are able to review and expand their knowledge of standard molecular techniques and are able to choose methods and techniques to design experiments in a specific research area.

### Courses

**V (3)**

Module taught in: English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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### Contents

Detailed insight into methods in bioinformatics; depending on the topic selected, fields covered include: genomics (sequence-, domain analysis and annotation), omics data analysis (NGS, transcriptomics, metabolomics, proteomics), topological and structural analysis of biological interactions including statistical methods, phylogenetic analysis, protein structure analysis. Results are documented in the form of a presentation, a publication or a term paper.

### Intended learning outcomes

Students have gained knowledge on experimental setups and methods used in the field of bioinformatics. They are able to design experiments, collect data and interpret them statistically, adhering to the principles of good scientific practice.

### Courses (type, number of weekly contact hours, language — if other than German)

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### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Module title
**Computational Biology F2**

### Abbreviation
07-MS3COBF2-152-m01

### Module coordinator
holder of the Chair of Bioinformatics

### Module offered by
Faculty of Biology

### ECTS
15

### Method of grading
(only) successfully completed

### Duration
1 semester

### Module level
graduate

### Other prerequisites
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### Contents
Advanced insight into methods in bioinformatics; depending on the topic selected, fields covered include: genomics (sequence-, domain analysis and annotation), omics data analysis (NGS, transcriptomics, metabolomics, proteomics), topological and structural analysis of biological interactions including statistical methods, phylogenetic analysis, protein structure analysis. The techniques applied are evaluated on the basis of the results obtained and are modified where necessary. Results are documented in the form of a presentation, a publication or a term paper.

### Intended learning outcomes
Proficiency in one or more methods in bioinformatics that allows students to successfully conduct scientific research (for their Master's thesis). Ability to independently address topics in bioinformatics as well as document and interpret findings, adhering to the principles of good scientific practice.

### Courses
- P (29) + S (1)

Module taught in: German and/or English

### Method of assessment

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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**Contents**

A broad variety of topics and concepts from the areas of neuroscience, infection and immunity, integrative biology, and biomedicine including for example: protein characterisation, DNA repair, Drosophila, computational biology, and neurocircuits.

**Intended learning outcomes**

Students have an overview of the current research topics in the Graduate School of Life Sciences and are able to explain their significance and scientific background.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3)

Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**

Practical course, summer school or workshop on specific topics in biology (duration: 6-9 weeks).

**Intended learning outcomes**

Proficiency in specific methods and lab techniques from selected fields of biology. Ability to apply these methods and techniques later on in a research project.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (30)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title
External Internship 2

### Abbreviation
07-MSA2-152-m01

### Module coordinator
Coordinator BioCareers

### Module offered by
Faculty of Biology

### ECTS
10

### Method of grading
Only after succ. compl. of module(s)

### (not) successfully completed
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### Duration
1 semester

### Module level
graduate

### Other prerequisites
Please consult with course advisory service in advance.

#### Contents
External placement on a biological topic. Students spend 4-6 weeks working on a well-defined scientific project and learn how to present their data.

#### Intended learning outcomes
Proficiency in selected methods and lab techniques from selected fields of biology. Ability to apply these methods and techniques later on in a research project.

#### Courses
(type, number of weekly contact hours, language — if other than German)

**P (15)**
Module taught in: German and/or English

#### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

#### Allocation of places
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#### Additional information
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#### Referred to in LPO I
(examination regulations for teaching-degree programmes)

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Module title | Abbreviation
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External Internship 3 | 07-MSA3-152-m01

**Coordinator**

BioCareers

**Module offered by**

Faculty of Biology

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**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

Please consult with course advisory service in advance.

**Contents**

External placement on a biological topic. Students spend 6-9 weeks working on a well-defined scientific lab project and learn how to present their data.

**Intended learning outcomes**

Proficiency in selected methods and lab techniques from selected fields of biology. Ability to apply these methods and techniques later on in a research project.

**Courses**

(type, number of weekly contact hours, language — if other than German)

P (30)

Module taught in: German and/or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Contents**

Practical course, summer school or workshop on specific topics in biology (duration: 2-3 weeks).

**Intended learning outcomes**

Proficiency in specific methods and lab techniques from selected fields of biology. Ability to apply these methods and techniques later on in a research project.

**Courses (type, number of weekly contact hours, language — if other than German)**

P (5)

Module taught in: German and/or English

**Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)**

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**

Practical course during stay abroad on a selected topic in biology (duration: 2-3 weeks).

**Intended learning outcomes**

Proficiency in selected methods and lab techniques from selected fields of biology. Ability to apply these methods and techniques later on in a research project.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (10)  Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Contents**

Introduction to the Linux operating system, writing computer programs using the programming language Perl to answer bioinformatic questions.

**Intended learning outcomes**

Students are able to use Linux as user and to write simple Perl scripts to answer bioinformatic questions.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (3)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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## Module title
Methods in Life Sciences

## Abbreviation
07-MLS1-152-m01

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## Contents
Versioned molecular techniques, lipid research methods, microscopic methods, immunohistochemistry, mouse models and gene-knockout approaches, protein and molecular biology techniques, PCR, advanced protein biochemistry, methods in bioinformatics and computational biology.

## Intended learning outcomes
Students are able to review and expand their knowledge of standard molecular techniques and are able to choose methods and techniques to design experiments in a specific research area.

## Courses (type, number of weekly contact hours, language — if other than German)
V (3)
Module taught in: English

## Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)
Language of assessment: English

## Allocation of places
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## Additional information
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**Contents**
A broad variety of topics and concepts from the areas of neuroscience, infection and immunity, integrative biology, and biomedicine including for example: protein characterisation, DNA repair, Drosophila, computational biology, and neurocircuits.

**Intended learning outcomes**
Students have an overview of the current research topics in the Graduate School of Life Sciences and are able to explain their significance and scientific background.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (3)
Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)
Language of assessment: English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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Module title: Current Methods in Biology B
Abbreviation: 07-MS31B-152-m01

Module coordinator: holder of the Chair of Plant Physiology and Biophysics
Module offered by: Faculty of Biology
ECTS: 7
Method of grading: Only after succ. compl. of module(s)
Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
This lecture series imparts the theoretical background of fundamental and up-to-date molecular biological methods in plant sciences. Special emphasis is placed on analytical tools, large-scale data analysis and their application.

Intended learning outcomes:
At the end of the lecture series, students will (I) be able to qualitatively evaluate results acquired with analytical and molecular biological methods and to integrate them into the context of the current scientific knowledge in this field (II) have gained an overview of the advantages/disadvantages of analytical and molecular biological approaches (III) be able to apply the knowledge they have acquired to design their own experimental strategies for addressing a specific research question.

Courses:
(type, number of weekly contact hours, language — if other than German)
V (3)
Module taught in: English

Method of assessment:
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)
Language of assessment: German and/or English

Allocation of places:
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Additional information:
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<tbody>
<tr>
<td>holder of the Chair of Ecophysiology and Vegetation Ecology</td>
<td>Faculty of Biology</td>
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<td>1 semester</td>
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**Contents**

The lecture will deal with the ecological and environmental constraints under which plants grow and develop (biogeography, biodiversity) and with the interactions of plants with abiotic and biotic environmental factors (e.g., plant-insect, plant-fungus interactions). The evolutionary adaptations on the physiological and organismic level will be emphasised in particular (stress and defence reactions, carnivory, plant protection). Corresponding experimental approaches will be illustrated.

**Intended learning outcomes**

Participants are able to identify and interpret ecological and ecophysiological interrelations and to discuss them in the context of the current state of knowledge in these fields.

**Courses** (type, number of weekly contact hours, language — if other than German)

- V (2)
  - Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<tr>
<td>Plant Immunobiology and Pharmaceutical Biology B</td>
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<td>holder of the Chair of Pharmaceutical Biology</td>
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**Contents**

This lecture addresses topics of pathogen recognition and signal transduction in plants, molecular and organi-
mic defence and the pharmaceutical relevance of plant-derived bioactive compounds. Plant immunobiology: in-
teractions between plants and pathogens comprise evolutionary dynamic and complex systems. Different stra-
tegies of the pathogens - bacteria, fungi and viruses - as well as defence mechanisms of the host plants will be
discussed. The molecular mechanisms of pathogen recognition, signal transduction, regulation of gene expres-
sion and activation of local and systemic defence responses are in the focus of this lecture. Differences and si-
milarities between plant and human immune systems will be pointed out. Understanding plant-pathogen-inter-
actions and molecular mechanisms determining susceptibility and defence is fundamental for the development
of strategies in plant protection. Evolution, function and pharmaceutical relevance of plant secondary metaboli-
tes: Secondary metabolites are part of effective plant defence strategies against microorganisms and herbivores
and are often essential for survival. The evolution of secondary metabolism will be discussed and general as well
as specific defence strategies will be explained. Pharmacological mechanisms of action and molecular targets of
important classes of plant bioactive compounds will be presented. A high proportion of currently used drugs ha-
ve been developed from plant secondary metabolites that have been used as lead structures to generate potent
drugs with improved pharmaceutical properties. Examples of therapies with very potent plant pharmaceuticals
(evidence-based medicine) as well as possibilities and limitations of phytotherapy (traditional medicine) will be
discussed.

**Intended learning outcomes**

Students are able to understand the interaction between plants and the environment on a molecular level and to
discuss the topic in the context of the scientific state of the art.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every seme-
ster, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually,
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questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of
up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title

Biophysics and Biochemistry B

### Abbreviation

07-MS3BBB-152-m01

### Module coordinator

holder of the Chair of Plant Physiology and Biophysics

### Module offered by

Faculty of Biology

### ECTS

5

### Method of grading

Only after succ. compl. of module(s)

### (not) successfully completed

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### Duration

1 semester

### Module level

graduate

### Other prerequisites

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### Contents

The module imparts theoretical and methodological knowledge of plant membrane transport, structural biology and biochemistry which is illustrated with specific examples from current research. Depending on the number of participants and their interests, practical demonstrations of methods that are currently used give students an opportunity to experience the practical aspects of biophysical and biochemical research.

### Intended learning outcomes

Students are able to use methods dealing with soluble proteins or membrane proteins in the fields of biophysics, structural biology and biochemistry. They are able to interpret the data and to discuss the results within the context of current knowledge.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2)
Module taught in: English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)
Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Module title | Abbreviation
--- | ---
Biophysics and Molecular Biotechnology B | 07-MS2BTB-152-m01

Module coordinator | Module offered by
holder of the Chair of Biotechnology and Biophysics | Faculty of Biology

ECTS | Method of grading | Only after succ. compl. of module(s)
--- | --- | ---
5 | numerical grade | --

Duration | Module level | Other prerequisites
--- | --- | ---
1 semester | graduate | --

Contents
This lecture provides a broad overview of biophysical techniques and their applications. The first part of the lecture discusses fundamental aspects of thermodynamics, kinetics and molecular interactions. The course then moves on to discuss biophysical methods that facilitate the investigation of individual cells down to the level of single molecules. Focus is on electromanipulation and dielectric spectroscopy of cells, electrokinetic techniques, biomembranes, electrophysiology, ion channels, protein folding, single-molecule fluorescence methods and high-resolution as well as dynamic microscopy.

Intended learning outcomes
Students will have acquired a knowledge of fundamental biophysical methods and their applications that will enable them to independently review relevant literature. In addition, they will have become acquainted with - or, where necessary, will be able to independently acquaint themselves with - biophysical mechanisms.

Courses (type, number of weekly contact hours, language — if other than German)
V (2)
Module taught in: English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)
Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Module title | Neurobiology, Behavioural Physiology and Animal Ecology B

Abbreviation | 07-MS1B-152-m01

Module coordinator | Dean of Studies Biologie (Biology)

Module offered by | Faculty of Biology

ECTS | 7

Method of grading | Only after succ. compl. of module(s)

(Not) successfully completed | --

Duration | 1 semester

Module level | graduate

Other prerequisites | --

Contents

Timing matters: Temporal organisation in the animal kingdom. Timing plays an important role in all living systems. Animals make use of endogenous clocks to predict and adapt to daily or seasonal changes in environmental parameters. To be at the right place at the right time is of great fitness relevance if – for example – a mating partner or enough food has to be found. Many mutualistic, antagonistic or social interactions can only take place if animals are at the same place at the same time and in the appropriate developmental stage. The lecture gives an introduction to the mechanisms underlying the temporal organisation in the animal kingdom. Adopting an integrative approach, the lecture goes from timing mechanisms on the neuronal level to individual behaviour and then to interactions in social groups, populations or partners in complex and variable ecosystems.

Intended learning outcomes

Students get to know the advantages of an integrative approach when analysing complex biological systems. They learn to relate and integrate different fields within biology.

Courses (type, number of weekly contact hours, language — if other than German)

V (3)

Module taught in: English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

Allocation of places

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Additional information

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<tr>
<td>holder of the Chair of Neurobiology and Genetics</td>
<td>Faculty of Biology</td>
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**Contents**

To understand how the brain controls behaviour is at the heart of neuroscience. Both brain and behaviour can be overwhelmingly complex and plastic, yet neurogenetic methods are powerful tools to dissect the principles of how the brain controls behaviour. The lecture and seminar will give a state-of-the-art view on current and important topics of behavioural neurobiology (incl. e.g. sleep, control of appetite and feeding, social behaviour, mating, mirror neurons, molecular mechanisms of auditory-guided behaviour, neurogenetic techniques) focusing on genetic model systems such as the fruit fly Drosophila, the mouse, and the nematode C. elegans.

**Intended learning outcomes**

In the lecture, students acquire theoretical and methodological insights into current topics in the field of neurogenetics in general and the neurogenetics of behaviour.

**Courses** (type, number of weekly contact hours, language — if other than German)

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**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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# Neuromodulation and Neuronal Development B

**Abbreviation**

07-MENMNDB-152-m01

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<td>holder of the Chair of Neurobiology and Genetics</td>
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## Contents

Neuromodulation: cellular and molecular biology of neuromodulators and their receptors, modulation of synaptic transmission and membrane potential, theoretical and functional aspects of neuromodulation, model systems used to study modulation of neuronal circuits. Fundamental principles of molecular developmental neurobiology. Focus is on the establishment of the neuroectoderm, pattern generation and regional specification, neuronal precursors, neuronal growth, differentiation of neurons, axonal pathfinding, neuronal connectivity.

## Intended learning outcomes

The students learn fundamental principles underlying neuromodulation and neuronal development and obtain an insight into current research in the field.

## Courses

V (3)

Module taught in: English

## Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

## Allocation of places

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## Additional information

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## Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Module title
Animal Ecology and Tropical Biology B

### Abbreviation
07-MTÖB-152-m01

### Module coordinator
holder of the Chair of Animal Ecology and Tropical Biology

### Module offered by
Faculty of Biology

### ECTS
5

### Method of grading
Only after succ. compl. of module(s)

### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

### Contents
This module consists of a lecture and a seminar. The lecture gives an overview of the theoretical foundations and current issues in animal ecology. Focus will be on biodiversity and ecosystem functions, multi-trophic interactions and food nets, evolutionary ecology, chemical ecology, tropical ecology, agricultural ecology, and global change.

### Intended learning outcomes
The students will acquire an advanced knowledge of ecological theories and current research issues in the field of animal ecology. They will be able to interpret scientific publications and apply the acquired knowledge to the solution of current environmental risks.

### Courses (type, number of weekly contact hours, language — if other than German)
V (2)
Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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Animal Ecology and Tropical Biology 2 B

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**Contents**

This module provides the fundamentals of the biology of tropical habitats and tropical communities. A special focus is on the global significance of tropical systems (ecosystem goods and ecosystem services), but the biological features of these highly diverse biomes are also highlighted.

**Intended learning outcomes**

The students will acquire deep knowledge of ecological theories and up-to-date research issues in the field of tropical ecology. They will be qualified to interpret scientific work and apply the knowledge they have acquired to the solution of current environmental risks.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2)

Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title

Animal Communication B

### Abbreviation

07-MKB-152-m01

### Module coordinator

holder of the Chair of Behavioral Physiology and Sociobiology

### Module offered by

Faculty of Biology

### ECTS

7

### Method of grading

(only after succinct completion of module(s))

### Duration

1 semester

### Module level

graduate

### Other prerequisites

--

### Contents

The lectures deal with physiological and neurobiological principles of the different communication channels used by animals, but also highlight adaptive values and evolutionary aspects of animal signalling.

### Intended learning outcomes

Students understand the value of an integrative approach when looking at complex issues in biology. They have learned to connect findings from different research areas, such as physiology, neurobiology, behaviour and ecological conditions, in order to gain a more complete picture of a topic. In addition, students have learned to present and discuss current scientific publications within a broader theoretical framework.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + S (1)

Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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## Module title
Experimental Sociobiology B

## Abbreviation
07-MESB-152-m01

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<td>1 semester</td>
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### Contents
The lectures highlight the diversity and the evolution of social behaviour, but also focus on the physiological, neurobiological and behavioural mechanisms underlying the organisation of social groups. In a follow-up seminar session, students will deepen their knowledge by presenting and discussing current papers related to the topic of the lecture.

### Intended learning outcomes
Students understand the value of an integrative approach when looking at complex correlations in behavioural biology. Students are able to recognise and interpret relationships between various aspects of sociobiology. They are able to formulate scientific questions in the context of sociobiology and are able to discuss cutting edge literature in depth.

### Courses (type, number of weekly contact hours, language — if other than German)
V (2) + S (1)

Module taught in: English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Module title: Molecular Biology B
Abbreviation: 07-MS2B-152-m01

Module coordinator: Dean of Studies Biologie (Biology)
Module offered by: Faculty of Biology

ECTS: 7
Method of grading: Only after successfully completed module(s)

Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
Molecular biology of the eukaryotic and prokaryotic cell. The lecture is a joint activity of the Chairs of Cell- and Developmental Biology, Microbiology, Biophysics and Bioinformatics and deals with concepts of modern molecular biology from the point of view of these different disciplines. Participants are recommended to read the textbook "Essential Cell Biology". The section on cell biology (approximately a quarter of the lecture) mainly discusses the eukaryotic cell and intends to elucidate the vast diversity in structure and function of molecules, organelles and cells in addition to fundamental principles of modern molecular cell biology. The bioinformatics section (approximately a quarter of the lecture) contains a large amount of examples for applications which allow the investigation of the molecular biology of a cell with bioinformatic tools. We closely adhere to the contents of the book "Essential Cell Biology" and present many clear and useful examples for the application of our tools when working on the topics of the other three Chairs. Our vision: bioinformatics essentially is molecular biology based on computing technology (time consuming "wet" experiments can be planned more easily and thus bioinformatics saves precious time). The microbiological section (approximately a quarter of the lecture) deals with fundamental molecular aspects of prokaryotic cells. Key aspects include the organisation of the bacterial genome, the transcription and translation machinery, mechanisms of regulation of gene expression, transport of small molecules and macromolecules, cell division and differentiation, bacterial motility and chemotaxis, signal transduction and bacterial communication mechanisms. Recommended reading: (a) Allgemeine Mikrobiologie (Fuchs) and (b) Biology of Microorganisms (Brock).

Intended learning outcomes
Master level knowledge about the molecular biology of the eukaryotic and prokaryotic cell.

Courses (type, number of weekly contact hours, language — if other than German)
V (3)
Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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Subdivided Module Catalogue for the Subject
MINT Teacher Education PLUS, Elite Network Bavaria (ENB)
120 ECTS credits

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<td>holder of the Chair of Microbiology</td>
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<td>1 semester</td>
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Contents
Fundamentals of molecular microbiology and infection biology, mechanisms of adherence and invasion, bacterial pathogenicity factors, regulation of virulence, mechanisms of host defence and pathogen interference, current methods in infection biology.

Intended learning outcomes
The students are able to understand fundamental theories of molecular microbiology and infection biology, emergence of infectious diseases.

Courses (type, number of weekly contact hours, language — if other than German)
V (2)
Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)
Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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<td>Pathogenicity of Microorganisms B</td>
<td>07-MS2PA-B-152-m01</td>
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**Contents**

Fundamental principles of the mode of action of microbial pathogenicity factors will be presented using selected prokaryotic and eukaryotic pathogens as model organisms. In addition, current research methods in infection biology will be presented.

**Intended learning outcomes**

Students have gained fundamental knowledge in infection biology and pathogenicity research and the mechanisms behind infectious diseases.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2)

Module taught in: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**

Advances and current results of bioinformatics are explained and discussed, this includes results from genome and sequence analysis, protein domains and protein families, large-scale data analysis (e.g. net generation sequences, proteomics data), analysis of different functional RNAs (e.g. miRNAs, IncRNAs).

**Intended learning outcomes**

Understand recent results in bioinformatics. Discuss their implications. Have an advanced (Master) level knowledge of typical technologies and research questions in bioinformatics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)
Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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</table>

**Contents**

Advances and current results of computational systems biology are explained and discussed, this includes results from functional genomics, dynamics of the transcriptome, of metabolism and metabolic networks as well as regulatory networks.

**Intended learning outcomes**

Understand recent results in systems biology. Discuss their implications. Have an advanced (Master) level knowledge of typical technologies and research questions of systems biology.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Contents**

This course will use a combination of lectures (daily) and practical experiments. Topics to be covered in the lecture (subject to change): - nuclear envelope, nuclear pores and nuclear-cytoplasmic transport. - nuclear envelope, nuclear lamina and their role in chromatin organisation and genetic diseases. - DNA, chromatin and chromosomes. - structure and function of nucleoli. - nuclear-cytoskeletal interactions.

**Intended learning outcomes**

Students are able to perform practical experiments, applying their theoretical knowledge.

**Courses** (type, number of weekly contact hours, language — if other than German)

Ü (5) + V (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (30 to 60 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title
Tropical Ecology

Abbreviation
07-MTROP-152-m01

Module coordinator
holder of the Chair of Animal Ecology and Tropical Biology

Module offered by
Faculty of Biology

ECTS
5

Method of grading
only after succ. compl. of module(s)

Duration
1 semester

Module level
graduate

Other prerequisites
--

Contents
Small projects on ecological or nature conservation-related issues will be implemented in a tropical ecosystem. Students should become familiar with different project stages from experiment design, implementation and data analysis through to data presentation. In evening seminars, recent publications in the field of tropical ecology will be presented and discussed.

Intended learning outcomes
The students will learn about various tropical ecosystems and will acquire advanced knowledge of ecological and nature conservation-related research in the tropics. They will learn field ecological methods for the quantitative detection of insects and their biotic interactions and will acquire statistical knowledge in the field of data analysis.

Courses
(type, number of weekly contact hours, language — if other than German)

Ü (3)
Module taught in: German and/or English

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I
(examination regulations for teaching-degree programmes)

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**Presentation of Scientific Data**

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**Module coordinator**

Coordinator BioCareers

**Module offered by**

Faculty of Biology

**ECTS**

5

**Method of grading**

Only after successfully completed module(s)

**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

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**Contents**

Principles for the preparation of scientific manuscripts, citations and the presentation of scientific data. Students will write a scientific mini review and present this in a talk (15 minutes). Content, structure, coherence and the logical chain of arguments will be discussed. Students will write and publish (where possible) a scientific paper or review on a selected topic in a scientific journal. The students' work will be based on original papers as well as on reviews and will follow the instructions of a scientific journal of the students' choice. These instructions can be found on the website of the respective journal under "Instructions to Authors" or similar. Both length of chapters and structure of the article should be based on the style of the journal selected. Attendance of no less than 20 scientific talks (e.g. defences of doctoral theses, presentations of research projects, retreats) including presentations by guest speakers. Students are to obtain proof of attendance from the organisers or speakers.

**Intended learning outcomes**

The students are familiar with the details of publishing scientific data in written and oral form. They have become familiar with the methodology of scientific publishing in oral or written fashion. In addition, they have enhanced their English reading, speaking and writing skills.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
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Quality Assurance, Good Practice, Biosafety and Biosecurity | 07-MGLN-152-m01

Coordinator | Module offered by
BioCareers | Faculty of Biology

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Contents

Political instruments to conserve biodiversity (convention on biodiversity (CBD), German strategy on biodiversity) as well as corporate social responsibility in the private economy, sponsoring and marketing are discussed. These topics are critically analysed with regard to sustainability, credibility and effectiveness. In addition, the students become familiar with strategies to prevent biodiversity loss and actively contribute to these activities. Good practice in the biosciences, quality assurance approaches and quality culture. Structure, idea and fundamental principles of quality management approaches, DIN EN ISO 9001, regulatory documents and framework in the biosciences including biotechnology, biosafety, biosecurity, risk assessment.

Intended learning outcomes

The students know relevant international conventions and German regulations on the conservation of biodiversity. They have become familiar with the regulatory and political framework for the conservation of biodiversity. They are aware of corporate responsibilities in this regard and know how to support cooperative approaches among companies and organisations on environmental protection. The students are familiar with the fundamental principles of "good practice" in research and development, and have understood the fundamental principles of quality management circles. They have developed a distinct sensitivity towards biosafety and biosecurity issues and know how to properly handle biological agents and organisms, including GMOs. In addition, they have developed a sensitivity towards the complex interdependencies in nature and are able to critically discuss socio-ethical issues in the bioscience area. Students possess the knowledge and skills required of a biosafety officer and are qualified for working in CSR or environmental management at major enterprises or mediating between environmental organisations, governments and the private sector.

Courses (type, number of weekly contact hours, language — if other than German)

V (1) + S (1)

Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, the following option will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions)

Language of assessment: German and/or English

Allocation of places

Additional information

Referred to in LPO I (examination regulations for teaching-degree programmes)
### Module title
**Special Subject Studies Biology and Natural Sciences 4**

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#### Module coordinator
Coordinator BioCareers

#### Module offered by
Faculty of Biology

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### Contents
Regular specific lecture, seminar, workshop, retreat or practical course (2 weekly contact hours) in biological or natural sciences with a graded assessment.

### Intended learning outcomes
Specific skills and knowledge on an interdisciplinary subject in the biological or natural sciences.

### Courses (type, number of weekly contact hours, language — if other than German)

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### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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Contents

Regular specific lecture, seminar, workshop, retreat or practical course (2 weekly contact hours) in biological or natural sciences; assessment ungraded, pass required.

Intended learning outcomes

Specific skills and knowledge on an interdisciplinary subject in the biological or natural sciences.

Courses (type, number of weekly contact hours, language — if other than German)

S (2)  
Module taught in: German and/or English  
Course type: might also be offered in V, Ü, P, R or E format

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

Allocation of places

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Additional information

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**Contents**

Regular specific lecture, seminar, workshop, retreat or practical course (3 weekly contact hours) in biological or natural sciences; assessment ungraded, pass required.

**Intended learning outcomes**

Specific skills and knowledge on an interdisciplinary subject in the biological or natural sciences.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (3)
Module taught in: German and/or English
Course type: might also be offered in V, Ü, P, R or E format

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Successful completion as certified by the lecturer
Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**

Regular specific lecture, seminar, workshop, retreat or practical course (3 weekly contact hours), offered by JMU or other institutions, in which students will acquire additional skills in areas other than biology or the natural sciences. Assessment ungraded, pass required (5 ECTS credits); decision on credit transfer to be made by module coordinators. Possible subjects are philosophy, pedagogy, history, languages, social studies, psychology, economics, and law.

**Intended learning outcomes**

Specific skills and knowledge on a specific subject in an area other than biology or the natural sciences.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)
- Module taught in: German and/or English
- Course type: might also be offered in V, Ü, P, R or E format

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)
- Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module title
Special Subject Studies outside Natural Sciences 4B

Abbreviation
07-MV4B-152-m01

Module coordinator
BioCareers

Module offered by
Faculty of Biology

ECTS
5

Method of grading
Only after succ. compl. of module(s)

Duration
1 semester

Module level
graduate

Other prerequisites
Please consult with course advisory service in advance.

Contents
Regular specific lecture, seminar, workshop, retreat or practical course (3 weekly contact hours), offered by JMU or other institutions, in which students will acquire additional skills in areas other than biology or the natural sciences. Assessment ungraded, pass required (5 ECTS credits); decision on credit transfer to be made by module coordinators. Possible subjects are philosophy, pedagogy, history, languages, social studies, psychology, economics, and law.

Intended learning outcomes
Specific skills and knowledge on a specific subject in an area other than biology or the natural sciences.

Courses (type, number of weekly contact hours, language — if other than German)

S (2)
Module taught in: German and/or English
Course type: might also be offered in V, Ü, P, R or E format

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) log (15 to 30 pages) or c) oral examination of one candidate each (30 to 60 minutes) or d) oral examination in groups of up to 3 candidates (30 to 60 minutes) or e) presentation (20 to 45 minutes)
Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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<td>07-DR4-152-m01</td>
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<tr>
<td>1 semester</td>
<td>undergraduate</td>
<td>Please consult with course advisory service in advance.</td>
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</table>

**Contents**

Students contribute to and/or independently organise courses for Bachelor's students or pupils. Students organising courses will receive advice on contents and organisation from the degree programme coordinator. The course will comprise 2 weekly contact hours.

**Intended learning outcomes**

Ability to independently organise courses.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (3)

Module taught in: German and/or English

Course type: might also be offered in V, Ü, P, R or E format

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Successful completion as certified by the lecturer

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
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<tr>
<td>Research Methods in Biology</td>
<td>07-GY-BFM-152-m01</td>
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<td>1 semester</td>
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### Contents

Overview of important traditional and modern methods in biology that are applied at the Chairs at the Biocentre, ranging from microscopy and chromatography to polymerase chain reaction (PCR).

### Intended learning outcomes

Knowledge of the fields of research the Faculty of Biology at the University of Würzburg is investigating.

### Courses (type, number of weekly contact hours, language — if other than German)

S (3)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 45 to 60 minutes)
- b) log (approx. 10 to 20 pages)
- c) oral examination of one candidate each (approx. 30 minutes)
- d) oral examination in groups of up to 3 candidates (approx. 20 minutes per candidate)
- e) presentation (approx. 20 to 30 minutes)
- f) practical examination (on average approx. 2 hours; time to complete will vary according to subject area but will not exceed a maximum of 4 hours)
- g) term paper (approx. 10 to 30 pages)
- h) project (approx. 10 to 30 pages)
- i) portfolio.

Students will be informed about the method and length of the assessment prior to the course.

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

§ 61 I Nr. 7
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<td>Research-oriented working in Biology</td>
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**Contents**

This module will acquaint students with procedures in biological laboratories. In the research-oriented practical course, students may choose from a range of topics offered by the Faculty of Biology. They will complete a scientific lab course.

**Intended learning outcomes**

Familiarity with fundamental concepts in statistics, e.g. mean value, standard deviation, standard error, creating graphs from raw data, insight into procedures in biological laboratories, deeper familiarity with research methods in a branch of biology, ability to experimentally address scientific problems, ability to design, perform and analyse experiments.

**Courses**

(type, number of weekly contact hours, language — if other than German)

Ü (4)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 45 to 60 minutes) or b) log (approx. 10 to 20 pages) or c) oral examination of one candidate each (approx. 30 minutes) or d) oral examination in groups of up to 3 candidates (approx. 20 minutes per candidate) or e) presentation (approx. 20 to 30 minutes) or f) practical examination (on average approx. 2 hours; time to complete will vary according to subject area but will not exceed a maximum of 4 hours) or g) term paper (approx. 10 to 30 pages) or h) project (approx. 10 to 30 pages) or i) portfolio.

Students will be informed about the method and length of the assessment prior to the course.

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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<td>Basic Human Biology I - GY</td>
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<td>1 semester</td>
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**Contents**

This module will be divided up into three sections covering the following topics:  
- human genetics (genetic disease, inheritance),  
- human physiology (human sensory physiology, nutrition, maintaining physical health),  
- human developmental physiology (sex organs, impregnation, embryonic development, evolutionary history of modern humans).

**Intended learning outcomes**

- Familiarity with the fundamental principles of human genetics

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 90 minutes)
creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 61 I Nr. 5
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<td>Basic Human Biology II</td>
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<td>holder of the Chair of Zoology I</td>
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<td>1 semester</td>
<td>undergraduate</td>
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**Contents**

Experiments to consolidate the students' knowledge of the topics covered in the lecture: We will examine preparations under the microscope, make drawings, develop genetic diagrams showing the inheritance of diseases, perform experiments on human physiology.

**Intended learning outcomes**

Students will be proficient in the theory and practice of research in the field of integrative behavioural biology and will have developed skills required for a career in research.

**Courses** (type, number of weekly contact hours, language — if other than German)

Ü (3)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Logs (approx. 30 hours) and 10 to 15 drawings creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 61 I Nr. 5
§ 41 I Nr. 5
### Module title
Advanced Microbiology - GY

### Abbreviation
07-GY-MIBI-152-m01

### Module coordinator
holder of the Chair of Microbiology

### Module offered by
Faculty of Biology

### ECTS
5

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
undergraduate

### Other prerequisites
Admission prerequisite to assessment: exercises. Regular attendance (minimum 80%) and successful completion of exercises (approx. 25 to 30 hours) are prerequisites for admission to assessment.

### Contents
During this lab course, students will deepen their knowledge of the topics covered in the module *Grundlagen der Mikrobiologie* (*Basic Microbiology*). Performing practical laboratory work, students will become familiar with molecular biological methods and approaches.

### Intended learning outcomes
Students have acquired a fundamental knowledge of methods in both classical microbiology and molecular biology. They are able to use these methods and to discuss current problems in these fields.

### Courses (type, number of weekly contact hours, language — if other than German)

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### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- written examination (approx. 60 minutes)
- creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)

§ 61 I Nr. 3
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<td>Information Transmission</td>
<td>10-I-IÜ-152-m01</td>
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<tbody>
<tr>
<td>holder of the Chair of Computer Science III</td>
<td>Institute of Computer Science</td>
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<tr>
<td>1 semester</td>
<td>undergraduate</td>
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</table>

### Contents

Introduction to probability calculus, coding theory, coding for fault detection and fault correction, information theory, spectrum and Fourier transform, modulation technique, structure of digital transmission systems, introduction to the structure of computer networks, communication protocols.

### Intended learning outcomes

The students possess a technical, theoretical and practical knowledge of the structure of systems for information transmission, a knowledge that is necessary to understand these systems.

### Courses (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

§ 22 II Nr. 3b
Module title: Algorithmic Graph Theory
Abbreviation: 10-I-AGT-152-m01

Module coordinator: holder of the Chair of Computer Science I
Module offered by: Institute of Computer Science

ECTS: 5
Method of grading: numerical grade
Only after succ. compl. of module(s): --

Duration: 1 semester
Module level: undergraduate
Other prerequisites: --

Contents:
We discuss typical graph problems: We solve round trip problems, calculate maximal flows, find matchings and colourings, work with planar graphs and find out how the ranking algorithm of Google works. Using the examples of graph problems, we also become familiar with new concepts, for example how we model problems as linear programs or how we show that they are fixed parameter computable.

Intended learning outcomes:
The students are able to model typical problems in computer science as graph problems. In addition, the participants are able to decide which tool from the course helps solve a given graph problem algorithmically. In this course, students learn in detail how to estimate the run time of given graph algorithms.

Courses:
(type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

Method of assessment:
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 22 II Nr. 3b
### Module title
Knowledge-based Systems

### Abbreviation
10-I-WBS-152-m01

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<td>holder of the Chair of Computer Science VI</td>
<td>Institute of Computer Science</td>
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<td>1 semester</td>
<td>undergraduate</td>
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</table>

### Contents
Foundations in the following areas: knowledge management systems, knowledge representation, solving methods, knowledge acquisition, learning, guidance dialogue, semantic web.

### Intended learning outcomes
The students possess theoretical and practical knowledge for the understanding and design of knowledge-based systems including knowledge formalisation and have acquired experience in a small project.

### Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English
creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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<th>Module title</th>
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<td>Data Mining</td>
<td>10-I-DM-152-m01</td>
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**Module coordinator**
holder of the Chair of Computer Science VI

**Module offered by**
Institute of Computer Science

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<td>Numerical grade</td>
<td>1 semester</td>
<td>Undergraduate</td>
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**Contents**
Foundations in the following areas: definition of data mining and knowledge, discovery in databases, process model, relationship to data warehouse and OLAP, data preprocessing, data visualisation, unsupervised learning methods (cluster and association methods), supervised learning (e.g. Bayes classification, KNN, decision trees, SVM), learning methods for special data types, other learning paradigms.

**Intended learning outcomes**
The students possess a theoretical and practical knowledge of typical methods and algorithms in the area of data mining and machine learning. They are able to solve practical knowledge discovery problems with the help of the knowledge acquired in this course and by using the KDD process. They have acquired experience in the use or implementation of data mining algorithms.

**Courses**
(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

**Allocation of places**

**Additional information**

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§ 22 II Nr. 3b
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<td>Object oriented Programming</td>
<td>10-I-OOP-152-m01</td>
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<td>Institute of Computer Science</td>
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**Contents**

Polymorphism, generic programming, meta programming, web programming, templates, document management.

**Intended learning outcomes**

The students are proficient in the different paradigms of object-oriented programming and have experience in their practical use.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- written examination (approx. 60 to 120 minutes).
- If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
- Language of assessment: German and/or English
- creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Theoretical Informatics</td>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
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</table>

**Contents**

- Computability, decidability, countability, finite automata, regular sets, generative grammars, context-free languages, context-sensitive languages, complexity of calculations, P-NP problem, NP completeness.

**Intended learning outcomes**

- The students possess a fundamental and applicable knowledge in the areas of computability, decidability, countability, finite automata, regular sets, generative grammars, context-free languages, context-sensitive languages, complexity of computations, P-NP problem, NP completeness.

**Courses** (type, number of weekly contact hours, language — if other than German)

- V (4)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- written examination (approx. 60 to 120 minutes).
  - If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

**Allocation of places**

- --

**Additional information**

- --

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

- § 49 I Nr. 1a
- § 69 I Nr. 1a
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<td>Tutorial Theoretical Informatics</td>
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**Module coordinator**
Dean of Studies Informatik (Computer Science)

**Module offered by**
Institute of Computer Science

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**Duration**
1 semester

**Module level**
undergraduate

**Other prerequisites**
--

**Contents**
Computability, decidability, countability, finite automata, regular sets, generative grammars, context-free languages, context-sensitive languages, complexity of calculations, P-NP problem, NP completeness.

**Intended learning outcomes**
The students possess a fundamental and applicable knowledge in the areas of computability, decidability, countability, finite automata, regular sets, generative grammars, context-free languages, context-sensitive languages, complexity of computations, P-NP problem, NP completeness.

**Courses** (type, number of weekly contact hours, language — if other than German)
Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) completion of approx. 11 exercises with approx. 4 components each (50% to be completed correctly) or b) written examination (approx. 180 to 240 minutes). Method of assessment to be selected by the candidate.

**Allocation of places**
--

**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
§ 49 I Nr. 1a
§ 69 I Nr. 1a
Module title | Abbreviation
---|---
Computer Architecture | 10-I-RAK-152-m01

Module coordinator
holder of the Chair of Computer Science V

Module offered by
Institute of Computer Science

ECTS | Method of grading | Only after succ. compl. of module(s)
---|---|---
5 | numerical grade | --

Duration | Module level | Other prerequisites
---|---|---
1 semester | undergraduate | --

Contents
Instruction set architectures, command processing through pipelining, statical and dynamic instruction scheduling, caches, vector processors, multi-core processors.

Intended learning outcomes
The students master the most important techniques to design fast computers as well as their interaction with compilers and operating systems.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English
creditable for bonus

Allocation of places
--

Additional information
--

Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 69 I Nr. 1c: Rechnerarchitektur
§ 22 II Nr. 3b
**Module title**  
Computer Networks and Communication Systems

**Abbreviation**  
10-I-RK-152-m01

**Module coordinator**  
holder of the Chair of Computer Science III

**Module offered by**  
Institute of Computer Science

**ECTS**  
8

**Method of grading**  
numerical grade

**Only after succ. compl. of module(s)**  
--

**Duration**  
1 semester

**Module level**  
undergraduate

**Other prerequisites**  
--

**Contents**


**Intended learning outcomes**

The students possess an intricate knowledge of the structure of computer networks and communication systems as well as fundamental principles to rate these systems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: German and/or English creditable for bonus

**Allocation of places**  
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**Additional information**  
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Practical course in hardware</td>
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<th>Other prerequisites</th>
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<tbody>
<tr>
<td>1 semester</td>
<td>undergraduate</td>
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</tbody>
</table>

**Contents**

Practical experiments on hardware aspects, for example in communication technology, robots or the structure of a complete microprocessor.

**Intended learning outcomes**

The students are able to independently review, prepare and perform experiments with the help of experiment descriptions, to independently search for additional information as well as to document and evaluate experiment results.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (6)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

portfolio: completion of approx. 3 to 10 project assignments (approx. 250 hours total) and presentation of results (approx. 10 minutes per project)

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 3b
Module title | Abbreviation
--- | ---
3D Point Cloud Processing | 10-I-3D-152-m01

Module coordinator | Module offered by
holder of the Chair of Computer Science VII | Institute of Computer Science

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<th>Other prerequisites</th>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>undergraduate</td>
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</tbody>
</table>

Contents
Laser scanning, Kinect and camera models, basic data structures (lists, arrays, oct-trees), calculating normals, k-d trees, registration, features, segmentation, tracking, applications for airborne mapping, applications to mobile mapping.

Intended learning outcomes
Students understand the fundamental principles of all aspects of 3D point cloud processing and are able to communicate with engineers / surveyors / CV people / etc. Students are able to solve problems of modern sensor data processing and have experienced that real application scenarios are challenging in terms of computational requirements, in terms of memory requirements and in terms of implementation issues.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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<tr>
<td>1 semester</td>
<td>undergraduate</td>
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</tbody>
</table>

**Contents**

Syntax and semantics of propositional logic, equivalence and normal forms, Horn formulas, SAT, resolution, infinite formula sets, syntax and semantics of predicate logic.

**Intended learning outcomes**

The students are proficient in the following areas: syntax and semantics of propositional logic, equivalence and normal forms, Horn formulas, SAT, resolution, infinite formula sets, syntax and semantics of predicate logic.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 3b
Module title | Abbreviation
--- | ---
Computational Complexity | 10-I-KT-152-m01

Module coordinator | Module offered by
Dean of Studies Informatik (Computer Science) | Institute of Computer Science

ECTS | Method of grading | Only after succ. compl. of module(s)
--- | --- | ---
5 | numerical grade | --

Duration | Module level | Other prerequisites
--- | --- | ---
1 semester | undergraduate | --

Contents
Complexity measurements and classes, general relationships between space and time classes, memory consumption versus computation time, determinism versus indeterminism, hierarchical theorems, translation methods, P-NP problem, completeness problems, Turing reduction, interactive proof systems.

Intended learning outcomes
The students possess a fundamental and applicable knowledge in the areas of complexity measurements and classes, general relationships between space and time classes, memory consumption versus computation time, determinism versus indeterminism, hierarchical theorems, translation methods, P-NP problem, completeness problems, Turing reduction, interactive proof systems.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 22 II Nr. 3b
Cryptography and Data Security

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<td>10-I-KD-152-m01</td>
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**Module coordinator**

Dean of Studies Informatik (Computer Science)

**Module offered by**

Institute of Computer Science

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</table>

**Duration**

1 semester

**Module level**

undergraduate

**Other prerequisites**

--

**Contents**

Private key cryptography systems, Vernam one-time pad, AES, perfect security, public key cryptography systems, RSA, Diffie-Hellman, Elgamal, Goldwasser-Micali, digital signature, challenge-response methods, secret sharing, millionaire problem, secure circuit evaluation, homomorphous encryption.

**Intended learning outcomes**

The students possess a fundamental and applicable knowledge in the areas of private key cryptography systems, Vernam one-time pad, AES, perfect security, public key cryptography, RSA, Diffie-Hellman, Elgamal, Goldwasser-Micali, digital signature, challenge-response method, secret sharing, millionaire problem, secure circuit evaluation, homomorphous encryption.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English
creditable for bonus

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 3b
### Module title
Seminar 1

### Abbreviation
10-I-SEM1-152-m01

### Module coordinator
Dean of Studies Informatik (Computer Science)

### Module offered by
Institute of Computer Science

### ECTS
5

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
undergraduate

### Other prerequisites
--

### Contents
Independent review of a current topic in computer science on the basis of literature and, where applicable, software with written and oral presentation. The topics in modules 10-I-SEM1 and 10-I-SEM2 must come from different areas (this usually means that they are assigned by different lecturers).

### Intended learning outcomes
The students are able to independently review a current topic in computer science, to summarise the main aspects in written form and to orally present these in an appropriate way.

### Courses
(type, number of weekly contact hours, language — if other than German)
S (2)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written elaboration (approx. 10 to 15 pages) and presentation (approx. 30 to 45 minutes) with subsequent discussion on a topic from the field of computer science
Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)
§ 22 II Nr. 3b
Module title: Project Presentation
Abbreviation: 10-I-PV-152-m01

Module coordinator: Dean of Studies Informatik (Computer Science)
Module offered by: Institute of Computer Science

ECTS: 5
Method of grading: numerical grade
Only after succ. compl. of module(s)

Duration: 1 semester
Module level: undergraduate
Other prerequisites: --

Contents
Presentation of a project developed by the student (e.g. Bachelor's thesis, software project) analogous to a presentation for laypersons with a knowledge of computer science at a trade fair. The project, which may also be work-in-progress, is presented with the help of a poster, a short talk and optionally a live demonstration.

Intended learning outcomes
The students are able to present a project they developed and to create the required media.

Courses
(type, number of weekly contact hours, language — if other than German)
S (5)

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

presentation of a project developed by the candidate analogous to a presentation for laypersons with a knowledge of computer science at a trade fair as well as discussion (approx. 10 to 15 minutes total)
Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 22 II Nr. 3b
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<tbody>
<tr>
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<td>Institute of Inorganic Chemistry</td>
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<tbody>
<tr>
<td>1 semester</td>
<td>undergraduate</td>
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**Contents**

German contents available but not translated yet.


**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Der/Die Studierende kann die Struktur und Eigenschaften von Metallen, Legierungen und salzartige Verbindungen fachgerecht darstellen. Er/Sie ist in der Lage, diese zu systematisieren und in Bezug auf Struktur und Reaktivität zu charakterisieren.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)
§ 22 II Nr. 2 f)
§ 62 I Nr. 1
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<td>Institute of Inorganic Chemistry</td>
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**Contents**

German contents available but not translated yet.

Das Modul vermittelt vertiefendes Wissen über Organometalle. Schwerpunkte sind Stuktur und Eigenschaften, Spezielle Stoffklassen, Reaktivität und Technische Prozesse.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Der/Die Studierende kann die Struktur und Eigenschaften von Organometallen fachgerecht darstellen. Er/Sie ist in der Lage, diese zu systematisieren und in Bezug auf Struktur und Reaktivität zu charakterisieren. Zudem kann er/sie Syntheseprinzipien für elementorganische Verbindungen entwickeln und erklären.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)
§ 22 II Nr. 2 f)
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<td>Institute of Organic Chemistry</td>
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### Contents

The module focuses on polar rearrangements, olefination reactions, pericyclic reactions, carbenes, nitriles and radicals. It imparts basic knowledge of stereoselective synthesis, asymmetric catalysis, organometallic chemistry and retrosynthesis.

### Intended learning outcomes

German intended learning outcomes available but not translated yet.


### Courses

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<td>V (2) + Ü (2)</td>
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### Method of assessment

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Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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§ 22 II Nr. 2 f)
§ 22 II Nr. 3 f)
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<tr>
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**Contents**

German contents available but not translated yet.

Das Modul behandelt biologisch wichtige Verbindungsklassen, deren Reaktionen und Synthesen, den Umgang mit besonderen Gefahrstoffen, anspruchsvollere Arbeits- und Synthesetechniken, Reinigungsmethoden und Produktanalytik.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.


**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)
§ 22 II Nr. 2 f)
§ 62 I Nr. 2
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<tr>
<td>lecturer of lecture &quot;Quantenchemie&quot;</td>
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### Contents
German contents available but not translated yet.


### Intended learning outcomes
German intended learning outcomes available but not translated yet.

Die Studierenden sind in der Lage, mit Hilfe grundlegender Konzepte und Modelle angeregte Zustände von Molekülen zu beschreiben.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)
§ 22 II Nr. 2 f)
§ 22 II Nr. 3 f)
Subdivided Module Catalogue for the Subject
MINT Teacher Education PLUS, Elite Network Bavaria (ENB)

Module title | Abbreviation
---|---
Symmetry, chemical bonding and light - Part 1 | 08-PC-SBL1-152-m01

Module coordinator | Module offered by
lecturer of lecture "Symmetrie, chemische Bindung and Licht" | Institute of Physical and Theoretical Chemistry

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<td>undergraduate</td>
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Contents
The module provides an introduction to the symmetry of molecules. It focuses on group theory, symmetry operations, point groups, character tables, and selection rules. The module deals with the chemical bond based on the qualitative MO theory and gives an introduction into the basics of computational chemistry.

Intended learning outcomes
The student is able to analyze the symmetry of molecules. He/She can imply on the spectroscopic properties of a molecule by its symmetry.

Courses
(type, number of weekly contact hours, language — if other than German)
V (3) + Ü (2)

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 22 II Nr. 1 h)  
§ 22 II Nr. 2 f)  
§ 22 II Nr. 3 f)
Module title: Molecular structure and spectroscopy
Abbreviation: 08-PC-MBS-152-m01

Module coordinator: Lecturer of lecture “Molekülbau and Spektroskopie”
Module offered by: Institute of Physical and Theoretical Chemistry

ECTS: 5
Method of grading: Only after succ. compl. of module(s)
Numerical grade: --

Duration: 1 semester
Module level: Undergraduate
Other prerequisites: --

Contents:
The module provides an introduction to the fundamental basics of molecular structure, spectroscopy and quantum mechanics. Via the particle in a box model and a quantum mechanical view of the hydrogen atom one gets to atomic orbitals, molecular orbitals and a basic understanding of the chemical bond. Molecules are analyzed based on the harmonic oscillator and the rigid rotor models. Spectroscopically focuses are UV/Vis spectroscopy, vibrational spectroscopy and rotational spectroscopy.

Intended learning outcomes:
The student is able to explain basic models of quantum mechanics and to apply them on molecules. He/She can outline different spectroscopically methods.

Courses (type, number of weekly contact hours, language — if other than German):
V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus):
a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)
Language of assessment: German and/or English
Creditable for bonus: --

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
§ 62 I Nr. 1
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<td>Module level</td>
<td>Depending on their choice of topic, students who are writing their Hausarbeit (thesis) pursuant to Section 29 LPO I (examination regulations for teaching-degree programmes) in the vertieft studiertes Fach (subject studied with a focus on the scientific discipline) Chemie (Chemistry) are highly recommended to complete module 08-Forsch-LAGY directly before completing module 08-Ch-HA-GY.</td>
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<tr>
<td>Other prerequisites</td>
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**Contents**

The module enables the processing of a defined problem within a specified period by applying the scientific methods learned in the course of study.

**Intended learning outcomes**

The student has the ability to deal with a defined problem/issue using scientific methods and to document the results.

**Courses** (type, number of weekly contact hours, language — if other than German)

| P | (16) |

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Log (approx. 20 pages)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 62 I Nr. 4
# Supramolecular Chemistry (Basics)

**Module title**  
Supramolecular Chemistry (Basics)

**Abbreviation**  
08-SCM-152-m01

**Module coordinator**  
lecturer of lecture "Organischen Chemie"

**Module offered by**  
Faculty of Chemistry and Pharmacy

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**Duration**  
1 semester

**Module level**  
graduate

**Other prerequisites**  
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**Contents**

German contents available but not translated yet.


**Intended learning outcomes**

German intended learning outcomes available but not translated yet.


**Courses (type, number of weekly contact hours, language — if other than German)**

S (3)

**Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)**

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes)

Language of assessment: German and/or English

**Allocation of places**  
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**Additional information**  
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**Referred to in LPO I**  
(examination regulations for teaching-degree programmes)

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**Module coordinator**

Lecturer of the seminar "Organo- and Biocatalyse"

**Module offered by**

Faculty of Chemistry and Pharmacy

**ECTS**

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**Contents**

German contents available but not translated yet.


**Intended learning outcomes**

German intended learning outcomes available but not translated yet.


**Courses** (type, number of weekly contact hours, language — if other than German)

S (3)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 45 to 90 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (15 to 30 minutes per candidate)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>lecturer of lecture “Klinisch-analytische Chemie” (Clinical and Analytical Chemistry)</td>
<td>Institute of Pharmacy and Food Chemistry</td>
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**Contents**

This module covers specific topics of clinical analytical chemistry.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Der/Die Studierende verfügt über Fortgeschrittenkenntnisse der Molekularbiologie.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 120 minutes)
Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title

Practical course of clinical-analytical Chemistry

### Abbreviation

08-PH-KACP-152-m01

### Module coordinator

Lecturer of lecture "Klinisch-analytische Chemie" (Clinical and Analytical Chemistry)

### Module offered by

Institute of Pharmacy and Food Chemistry

### ECTS

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### Contents

German contents available but not translated yet.

Das Modul behandelt praktische Themen der Klinischen Chemie sowie der Klinischen Diagnostik und die dazugehörigen analytischen Methoden.

### Intended learning outcomes

German intended learning outcomes available but not translated yet.

Der/Die Studierende verfügt über Kenntnisse der Klinisch-analytischen Chemie und kann die Inhalte in praktischen Versuchen anwenden.

### Courses

(type, number of weekly contact hours, language — if other than German)

P (5)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Vortestate/Nachtestate (pre and post-experiment examination talks approx. 15 minutes each, log approx. 5 to 10 pages each) and assessment of practical performance (2 to 4 random examinations)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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**Contents**

German contents available but not translated yet.


**Intended learning outcomes**

German intended learning outcomes available but not translated yet.


**Courses** (type, number of weekly contact hours, language — if other than German)

S (3)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 45 to 90 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (15 to 30 minutes per candidate)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title
Molecular Materials (Lecture)

### Abbreviation
08-FU-MoMaV-152-m01

### Module coordinator

**Degree programme coordinator Funktionswerkstoffe (Functional Materials)**

### Module offered by
Chair of Chemical Technology of Material Synthesis

### ECTS
5

### Method of grading

**Numerical grade**

**Only after succ. compl. of module(s)**

### Duration
1 semester

### Module level
undergraduate

### Other prerequisites
--

### Contents
Chemical bonds and molecular interactions, supramolecular chemistry, molecular materials, colloids, nanoparticles, thin films.

### Intended learning outcomes
The students gain fundamental knowledge in the relationships of physical, chemical and technological properties of materials and their structure. They understand the significance of various inter- and intramolecular interactions and how they determine the properties of molecular materials. They learn how to familiarize themselves with a scientific topic including a literature search, and how to give a presentation including discussion and feedback.

### Courses
(type, number of weekly contact hours, language — if other than German)

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### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes) as well as talk (approx. 30 minutes), weighted 3:1

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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<td>degree programme coordinator Funktionswerkstoffe (Functional Materials)</td>
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</table>

**Contents**

Synthesis methods and parameters in sol-gel chemistry as well as characterisation and application of created materials. Basic principles of bio-mineralisation, structure of biomaterials and introduction to bio-inspired materials synthesis.

**Intended learning outcomes**

The student possesses profound knowledge about sol-gel chemistry and biomineralisation.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<tr>
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</table>

**Contents**


**Intended learning outcomes**

The students possess comprehensive knowledge about various techniques form different areas of the field of chemical process engineering. For a given objective they are able to weigh the pros and cons of different techniques and can suggest ways of fabrication, processing and treatment of materials. Furthermore they are confident in handling of measurement data as well as statistical and systematic errors and possess extensive knowledge about nomenclature, significance as well as practically determining characteristic material properties.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title

**Material Science 2 (The Material Groups)**

### Abbreviation

08-FU-MaWi2-152-m01

### Module coordinator

holder of the Chair of Chemical Technology of Material Synthesis

### Module offered by

Chair of Chemical Technology of Material Synthesis

### ECTS

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<td>1 semester</td>
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### Contents


### Intended learning outcomes

The students acquire fundamental knowledge about fabrication and properties of the major classes of materials and are able to apply this to scientific problems.

### Courses (type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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**Contents**

Advanced topics in automation systems as well as instrumentation and control engineering, for example from the field of sensor data processing, actuators, cooperating systems, mission and trajectory planning.

**Intended learning outcomes**

The students have an advanced knowledge of selected topics in automation systems. They are able to implement advanced automation systems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes) creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title
Robotics 1

### Abbreviation
10-I=RO1-152-m01

### Module coordinator
holder of the Chair of Computer Science VII

### Module offered by
Institute of Computer Science

### ECTS
8

### Method of grading
Numerical grade

### Only after succ. compl. of module(s)
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### Duration
1 semester

### Module level
Graduate

### Other prerequisites
--

### Contents
History, applications and properties of robots, direct kinematics of manipulators: coordinate systems, rotations, homogenous coordinates, axis coordinates, arm equation. Inverse kinematics: solution properties, end effector configuration, numerical and analytical approaches, examples of different robots for analytical approaches. Workspace analysis and trajectory planning, dynamics of manipulators: Lagrange-Euler model, direct and inverse dynamics. Mobile robots: direct and inverse kinematics, propulsion system, tricycle, Ackermann steering, holonomic and non-holonomic restrictions, kinematic classification of mobile robots, posture kinematic model. Movement control and path planning: roadmap methods, cell decomposition methods, potential field methods. Sensors: position sensors, speed sensors, distance sensors.

### Intended learning outcomes
The students master the fundamentals of robot manipulators and vehicles and are, in particular, familiar with their kinematics and dynamics as well as the planning of paths and task execution.

### Courses
V (4) + Ü (2)

### Method of assessment
Written examination (approx. 60 to 90 minutes) creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

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**Contents**

Foundations of dynamic systems, controllability and observability, controller design through pole assignment: feedback and feed-forward, state observer, feedback with state observer, time discrete systems, stochastic systems: foundations of stochastics, random processes, stochastic dynamic systems, Kalman filter: derivation, initialising, application examples, problems of Kalman filters, extended Kalman filter.

**Intended learning outcomes**

The students master all fundamentals that are necessary to understand Kalman filters and their use in applications of robotics. The students possess a knowledge of advanced controller and observer methods and recognise the connections between the dual pairs controllability - observability as well as controller design and observer design. They also recognise the relationship between the Kalman filter as a state estimator and an observer.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 90 minutes) creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Exam Tutorial for the German Staatsexamen

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#### Module coordinator
Dean of Studies Informatik (Computer Science)

#### Module offered by
Institute of Computer Science

#### ECTS
4

#### Method of grading
Only after successfully completed

#### Duration
2 semester

#### Module level
undergraduate

#### Other prerequisites
--

### Contents
Revision of contents of modules covering the subject as well as the subject didactics of computer science.

### Intended learning outcomes
The students have refreshed their skills for the solution of the type of problems asked in the written state examination.

### Courses
(2)

#### Ü (2)

### Method of assessment
One exercise per area covered in the state examination

### Allocation of places
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### Additional information
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### Referred to in LPO I
(Examination regulations for teaching-degree programmes)

§ 22 II Nr. 2 f)
§ 22 II Nr. 3b
<table>
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<td>Digital computer systems</td>
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**Contents**

Introduction to digital technologies, Boolean algebras, combinatorial circuits, synchronous and asynchronous circuit hardware description languages, structure of a simple processor, machine programming, memory hierarchy.

**Intended learning outcomes**

The students possess a knowledge of the fundamentals of digital technologies up to the design and programming of easy microprocessors as well as knowledge for the application of hardware description languages for the design of digital systems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 69 I Nr. 1c: Rechnerarchitektur
§ 22 II Nr. 3b
Module title | Abbreviation
---------------|-----------------|
Tutorial Digital computer systems | 10-I-RALT-152-m01

Module coordinator | Module offered by
holder of the Chair of Computer Science V | Institute of Computer Science

ECTS | Method of grading | Only after succ. compl. of module(s)
5 | (not) successfully completed | --

Duration | Module level | Other prerequisites
1 semester | undergraduate | --

Contents
Introduction to digital technologies, Boolean algebras, combinatorial circuits, synchronous and asynchronous circuit hardware description languages, structure of a simple processor, machine programming, memory hierarchy.

Intended learning outcomes
The students possess a knowledge of the fundamentals of digital technologies up to the design and programming of easy microprocessors as well as knowledge for the application of hardware description languages for the design of digital systems.

Courses (type, number of weekly contact hours, language — if other than German)
Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) completion of approx. 11 exercises with approx. 4 components each (50% to be completed correctly) or
b) written examination (approx. 180 to 240 minutes). Method of assessment to be selected by the candidate.

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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### Contents

Computer graphics studies methods for digitally synthesising and manipulating visual content. This course specifically concentrates on interactive graphics with an additional focus on 3D graphics as a requirement for many contemporary as well as for novel human-computer interfaces and computer games. The course will cover topics about light and images, lighting models, data representations, mathematical formulations of movements, projection as well as texturing methods. Theoretical aspects of the steps involved in ray-tracing and the raster pipeline will be complemented by algorithmical approaches for interactive image syntheses using computer systems. Accompanying software solutions will utilise modern graphics packages and languages like OpenGL, GLSL and/or DirectX.

### Intended learning outcomes

At the end of the course, the students will have a broad understanding of the underlying theoretical models of computer graphics. They will be able to implement a prominent variety of these models, to build their own interactive graphics applications and to choose the right software tool for this task.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: German and/or English creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Contents

Selected topics in algorithmics and theory.

### Intended learning outcomes

The students understand the basic approach of algorithmic and theoretical computer science. They are able to understand the solutions to complex problems in this area and to apply them to similar questions.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

§ 22 II Nr. 3b
Multimodal User Interfaces

Multimodal User Interfaces simultaneously uses various modalities like speech, gesture, touch, or gaze, to communicate with computers and machines. Basically, multimodal interaction includes the analysis as well as the synthesis of multimodal utterances. This course concentrates on the analysis, i.e., the input processing. Input processing has the goal to derive meaning from signal to provide a computerized description and understanding of the input and to execute the desired interaction. In multimodal systems, this process is interleaved between various modalities and multiple interdependencies exist between simultaneous utterances necessary to take into account for a successful machine interpretation.

In this course, students will learn about the necessary steps involved in processing unimodal as well as multimodal input. The course will highlight typical stages in multimodal processing. Using speech processing as a primary example, they learn about:

1. A/D conversion
2. Segmentation
3. Syntactical analysis
4. Semantic analysis
5. Pragmatic analysis
6. Discourse analysis

A specific emphasize will be on stages like morphology and semantic analysis. Typical aspects of multimodal interdependencies, i.e., temporal and semantic interrelations are highlighted and consequences for an algorithmic processing are derived. Prominent multimodal integration (aka multimodal fusion) approaches are described, including transducers, state machines, and unification.

Intended learning outcomes

After the course, the students will be able to build their own multimodal interfaces. They will have a broad understanding of all the necessary steps involved and will know prominent algorithmic solutions for each of them. Student will learn about available tools for reoccurring tasks and their pros and cons.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
presentation of project results
Language of assessment: German and/or English
creditable for bonus

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 22 II Nr. 3b
### Module title

Introduction into Human-Computer Interaction

### Abbreviation

06-HCI=Einf-152-m01

### Module coordinator

holder of the Chair of Computer Science IX

### Module offered by

Institute of Computer Science

### ECTS

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### Contents

Human-Computer Interaction is concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. This course gives an introduction into the principle biological, physiological, and psychological constraints as defined by the human user and relates these constraints to the conceptual and technical solutions of today’s computer systems and existing as well as prospective interaction metaphors between humans and computers.

The course covers topics about human perception and cognition, memory and attention, the design of interactive systems, prominent evaluation methods, the principles of computer systems, typical input processing techniques, interface technology, and examples of typical interaction metaphors, from text-based input to graphical desktops to multimodal interfaces. Accompanying lab-work will introduce students to typical tasks involved in this field, i.e., prominent evaluation methods and prototyping of interfaces.

### Intended learning outcomes

After the course, the students will have a broad understanding of the underlying principles of human users and computer systems. They will understand the constraints and capabilities of current user interfaces and they will learn about the necessary steps applied in user-centered design and development approaches.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

presentation of project results

Language of assessment: German and/or English

creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

§ 22 II Nr. 3b
### Module title
3D User Interfaces

### Abbreviation
06-HCl=IS-152-m01

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### Contents
This module will give students the opportunity to learn about the specificities of 3D User Interfaces (3DUI) development using Virtual, Augmented or Mixed Reality technologies. The module content will be mainly dedicated to learn and practice the skills essential to the design and implementation of high-quality 3D interaction techniques. Design guidelines as well as classical and innovative 3D interaction techniques will be studied. In addition, the course will address novel research themes such as 3D interaction for large displays and games; and integrating 3DUIs with mobile devices, robotics, and the environment. Students will be assessed through a group practical project (team work), which will consist of a program, a presentation, a technical report (2 ages) and a video. Previous years, the assignment replicated the IEEE 3DUI Contest 2011, where teams of students competed between each other to find the best solution (see results at [https://www.youtube.com/watch?v=gYs-pBW7Agc](https://www.youtube.com/watch?v=gYs-pBW7Agc) and [https://www.youtube.com/watch?v=gYs-pBW7Agc](https://www.youtube.com/watch?v=gYs-pBW7Agc)).

### Intended learning outcomes
After the course, the students will gain a solid background on the theory and the methods to create your own 3D spatial interfaces. They will have a broad understanding of the particular difficulties of designing and developing spatial interfaces, as well as evaluating then. Students will also learn about traditional and novel 3D input/output devices (e.g., motion tracking system and Head-mounted Display).

### Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
presentation of project results
Language of assessment: German and/or English
creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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Contents

This course provides an introduction into the requirements, concepts, and engineering art of highly interactive human-computer systems. Such systems are typically found in perceptual computing, Virtual, Augmented, Mixed Reality, computer games, and cyber-physical systems. Lately, these systems are often termed Real-Time Interactive Systems (RIS) due to their common aspects.

The course covers theoretical models derived from the requirements of the application area as well as common hands-on and novel solutions necessary to tackle and fulfill these requirements. The first part of the course will concentrate on the conceptual principles characterizing real-time interactive systems. Questions answered are: What are the main requirements? How do we handle multiple modalities? How do we define the timeliness of RIS? Why is it important? What do we have to do to assure timeliness? The second part will introduce a conceptual model of the mission-critical aspects of time, latencies, processes, and events necessary to describe a system's behavior. The third part introduces the application state, its requirements of distribution and coherence, and the consequences these requirements have on decoupling and software quality aspects in general. The last part introduces some potential solutions to data redundancy, distribution, synchronization, and interoperability. Along the way, typical and prominent state-of-the-art approaches to reoccurring engineering tasks are discussed.

This includes pipeline systems, scene graphs, application graphs (aka field routing), event systems, entity and component models, and others. Novel concepts like actor models and ontologies will be covered as alternative solutions. The theoretical and conceptual discussions will be put into a practical context of today's commercial and research systems, e.g., X3D, instant reality, Unity3d, Unreal Engine 4, and Simulator X.

Intended learning outcomes

After the course, the students will have a solid understanding of the boundary conditions defined by both, the physiological and psychological characteristics of the human users as well as by the architectures and technological characteristics of today's computer systems. Participants will gain a solid understanding about what they can expect from today's technological solutions. They will be able to choose the appropriate approach and tools to solve a given engineering task in this application area and they will have a well-founded basis enabling them to develop alternative approaches for future real-time interactive systems.

Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes)
Language of assessment: German and/or English creditable for bonus

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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<th>Module offered by</th>
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<tr>
<td>holder of the Chair of Functional Materials in Medicine and Dentistry</td>
<td>Faculty of Medicine</td>
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<td>1 semester</td>
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</table>

**Contents**

Basic methods of polymerisation: free radical polymerisations, polyadditions, ionic polymerisations, controlled radical polymerisations; characterisation of polymers and polymer analytics: gel permeation chromatography, endgroup analysis, mass spectrometry, rheology.

**Intended learning outcomes**

The students acquire fundamentals of polymer chemistry and the related methods for their characterisation.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + P (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) assessment and b) Vortestate/Nachtestate (pre and post-experiment examination talks approx. 15 minutes each, log approx. 5 to 10 pages each) and assessment of practical assignments (2 to 4 random examinations)

Assessment offered: Once a year, winter semester

Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<tr>
<td>Managing Director of the Institute of Applied Physics</td>
<td>Faculty of Physics and Astronomy</td>
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**Contents**

Nuclear Physics: experimental methods, detectors, structure of the atomic nucleus, radioactivity, nuclear fission, technical and medical applications, radiation protection. Elementary Particle Physics: Particle accelerator, classification of elementary particles, fundamental interactions. Astrophysics: Stellar development, structure of the Sun, cosmology.

**Intended learning outcomes**

The students have structured knowledge of the aforementioned terms; they know relevant key concepts and experiments as well as measuring methods and dimensions of central values; they are able to work on simple relevant problems in a quantitative manner.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)

Module taught in: Ü: German or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 90 to 120 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

§ 77 I Nr. 1 b)
**Module title**

General Concepts of Physics

**Abbreviation**

11-L-GKP-152-m01

**Module coordinator**

Managing Director of the Institute of Applied Physics

**Module offered by**

Faculty of Physics and Astronomy

**ECTS**

6

**Method of grading**

Only after succ. compl. of module(s)

**Duration**

1 semester

**Module level**

undergraduate

**Other prerequisites**

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**Contents**

This module focuses on important concepts and applications that constitute interconnections between the sub-disciplines of Physics (and partly other Natural Sciences). When it comes to concepts, these interconnections are structural, they are elements of the physical terminology and belong to the mental structure of the subject. Applied Physics: synergetic interconnections between elements of knowledge of the corresponding subdiscipline and beyond which are necessary for the solution of many important problems. On both levels, the specific contents and the resulting interconnections have the same significance. Structures and concepts: Dimensional analysis, scaling, similitude theory; fields; interactions; symmetries and conserved quantities, wave equation, waves; multipoles among other mode analysis; non-linear dynamics, self-organisation, deterministic chaos; analogies of transport phenomena; Virial theorem as a structural element; microscopic modelling of macroscopic phenomena; scattering and structure determination; aspects of the history of ideas of important concepts and their controversies (e.g. atomism, determinism); Applied and Technical Physics: Physics and information/communication technology; rules and process technology, sensors; medical technology; climate and weather; Biophysics; ecology; energy; celestial mechanics, satellites, GPS; measuring devices; el. light sources; displays

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**Intended learning outcomes**

Their understanding of important shared concepts enables the students to connect different subdisciplines of Physics, they know the similarities and differences of different usage contexts and therefore have in-depth knowledge of these concepts and are able to mathematically describe and process relevant problems on the level of Theoretical Physics; they understand complex systems of nature and engineering and are able to connect their own physical knowledge in a synergetic manner by analysing the solutions to selected, complex problems, they are able to explain the interactions of knowledge of different disciplines for the solution of complex problems on the basis of selected examples.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1) + S (2)

Module taught in: Ü: German or English

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**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes)

Language of assessment: German and/or English

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**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Endogenous Clocks B</td>
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**Module coordinator**

holder of the Chair of Neurobiology and Genetics

**Module offered by**

Faculty of Biology

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**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

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**Contents**

Introduction into endogenous clocks of unicellular organisms, fungi, plants and animals, with a focus on the neuronal organisation of the clock in the brain of mammals and insects. The biological functions of endogenous clocks and the underlying mechanisms will be discussed on the molecular, cellular and organismic levels. It will be explained how clocks adjust to a 24h day with variable photoperiods. Applied aspects regarding e. g. shift work or jetlag will also be discussed.

**Intended learning outcomes**

The students learn fundamental principles underlying chronobiology/endogenous clocks and obtain an insight into current research in the field.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Students will be informed about the method, length and scope of the assessment prior to the course. Usually, one of the following options will be chosen: a) written examination (30 to 60 minutes, including multiple choice questions) or b) oral examination of one candidate each (30 to 60 minutes) or c) oral examination in groups of up to 3 candidates (approx. 30 to 60 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**


**Intended learning outcomes**

The student is acquainted with the fundamental notions, methods and results of higher analysis. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and questions in physics and other natural and engineering sciences.

**Courses (type, number of weekly contact hours, language — if other than German)**

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)**

a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Contents**

Contemporary topics in algebra, for example coding theory, elliptic curves, algebraic combinatorics or computer algebra.

**Intended learning outcomes**

The student is acquainted with fundamental concepts and methods in a contemporary field of algebra, and is able to apply these skills to complex questions.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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</table>

**Contents**

Central and advanced results in differential geometry, in particular about differentiable and Riemannian manifolds.

**Intended learning outcomes**

The student is acquainted with concepts and methods for differentiable manifolds or Riemannian manifolds, is able to apply these methods and knows about the interaction of local and global methods in differential geometry.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

creditable for bonus

**Allocation of places**

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**Additional information**

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**Contents**

In-depth study of mapping properties of analytic functions and their generalisations with modern analytic and geometric methods. Structural properties of families of holomorphic and meromorphic functions. Special functions (e.g., elliptic functions).

**Intended learning outcomes**

The student is acquainted with the fundamental notions, methods and results of higher complex analysis, in particular the (geometric) mapping properties of holomorphic functions. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and applications in other subjects.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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</table>

**Contents**

Tits buildings, generalised polygons or related geometric structures, automorphisms, BN pairs in groups, Moufang conditions, classification results.

**Intended learning outcomes**

The student is acquainted with the fundamental notions, methods and results concerning a type of geometric structure. He/She is able to establish a connection between these results and broader theories, and learns about the interactions of geometry and other fields of mathematics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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## Industrial Statistics 1

**Module title:** Industrial Statistics 1  
**Abbreviation:** 10-M=AIST-161-m01  

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</table>

### Contents

Theory of parameter and domain estimates, tests for statistical estimates, distribution models, empirical distribution analysis, comparative analysis, statistical product testing, survey sampling, audit sampling.

### Intended learning outcomes

The student masters the fundamental statistical methods for industrial applications.

### Courses (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)  
Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 90 to 120 minutes, usually chosen)  
- b) oral examination of one candidate each (approx. 20 minutes)  
- c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester.
Language of assessment: German or English.
Creditable for bonus.

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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**Contents**

Linear Lie groups and their Lie algebras, exponential function, structure and classification of Lie algebras, classic examples, applications, e. g. in physics and control theory.

**Intended learning outcomes**

The student is acquainted with the fundamental results, theorems and methods in Lie theory. He/She is able to apply these to common problems, and knows about the interactions of group theory, analysis, topology and linear algebra.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**
Discretisation of elliptic differential equations, classical iteration methods, preconditioners, multigrid methods.

**Intended learning outcomes**
The student is acquainted with the most important methods for solving large systems of equations, and knows the most efficient way to solve a given system of equations.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English
creditable for bonus

**Allocation of places**
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**Additional information**
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<td>Basics in Optimization</td>
<td>10-M=AOPT-161-m01</td>
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<td>1 semester</td>
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**Contents**

Fundamental methods and techniques in continuous optimization, unrestricted optimization, conditions for optimality, restricted optimization, examples and applications in natural and engineering sciences as well as economics.

**Intended learning outcomes**

The student knows the fundamental methods of continuous optimization, can judge their strengths and weaknesses and can decide which method is the most suitable in applications.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

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**Contents**

Introduction to mathematical systems theory: stability, controllability and observability, state feedback and stability, basics in optimal control.

**Intended learning outcomes**

The student is acquainted with the fundamental notions and methods of control theory. He/She is able to establish a connection between these results and broader theories, and learns about the interactions of geometry and other fields of mathematics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
---|---
Stochastic Models of Risk Management | 10-M=ASMR-161-m01

Module coordinator | Module offered by
---|---
Dean of Studies Mathematik (Mathematics) | Institute of Mathematics

ECTS | Method of grading | Only after succ. compl. of module(s)
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10 | numerical grade | --

Duration | Module level | Other prerequisites
---|---|---
1 semester | graduate | --

Contents
Measure theory, risk diagrams, failure mode and effects analysis, risk assessment in auditing, shortfall measures, value at risk, conditional value at risk, axiomatic of risk measures, modelling of interdependencies, copula, modelling of functional interrelations, regression models, basics in time series modelling, aggregated losses, estimates of shortfall measures, estimates of value at risk and conditional value at risk, basics in empirical time series analysis, methods of exponential smoothing, predictions and prediction domains, estimates of value at risk in time series, elementary empirical regression analysis, simulation methods.

Intended learning outcomes
The student is acquainted with the fundamental methods of stochastic risk analysis.

Courses (type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)
Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Allocation of places
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Additional information
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### Stochastical Processes

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#### Contents

Markov chains, queues, stochastic processes in C[0,1], Brownian motion, Donsker's theorem, projective limits.

#### Intended learning outcomes

The student is acquainted with the fundamental notions and methods of stochastical processes and can apply them to practical problems.

#### Courses

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Language of assessment: German or English

creditable for bonus

#### Allocation of places

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#### Additional information

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**Contents**

Set-theoretic topology, topological invariants (e.g. fundamental group, connection), construction of topological spaces, covering spaces.

**Intended learning outcomes**

The student is acquainted with the fundamental results, theorems and methods in topology and is able to apply these to common problems.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

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**Contents**

The module discusses policies on one life: distributions of future lifetime, life tables, life table approximations, types of benefits, present value, expectation principle, premium calculation, commutation functions, reserves and policy values, expenses, bonus, recursive methods, Thiele's differential equation.

**Intended learning outcomes**

The student is acquainted with the fundamental notions and methods of life insurance mathematics and can apply them to practical problems.

**Courses** *(type, number of weekly contact hours, language — if other than German)*

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment** *(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)*

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Language of assessment: German or English

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**Module coordinator**  
Dean of Studies Mathematik (Mathematics)

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**Duration**  
1 semester

**Module level**  
graduate

**Other prerequisites**  
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**Contents**  
Additive model, linear filters, autocorrelation, moving average, autoregressive processes, Box-Jenkins method.

**Intended learning outcomes**  
The student is acquainted with the fundamental methods of time series analysis and can apply them to practical problems.

**Courses**  (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)  
Module taught in: German and/or English

**Method of assessment**  (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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**Contents**
Number-theoretic functions and their associated Dirichlet series resp. Euler products, their analytic theory with applications to prime number distribution and diophantine equations; discussion of the Riemann hypothesis, overview of the development of modern number theory.

**Intended learning outcomes**
The student is acquainted with the fundamental methods of analytics number theory, can deal with algebraic structures in number theory and knows methods for the solution of diophantine equations. He/She has insight into modern developments in number theory.

**Courses**
(type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

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### Contents
In-depth discussion of a specialised topic in analysis taking into account recent developments and interrelations with other mathematical concepts.

### Intended learning outcomes
The student is acquainted with advanced results in a selected topic in analysis, and is able to apply these to complex problems.

### Courses (type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)
Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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<td>Homology, homotopy invariance, exact sequences, cohomology, application to the topology of Euclidean spaces.</td>
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<th>Intended learning outcomes</th>
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<td>The student is acquainted with advanced results in algebraic topology.</td>
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**Module coordinator**

Dean of Studies Mathematik (Mathematics)

**Module offered by**

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**Contents**

Selected topics in financial mathematics, e.g. conditional expectation and martingales, fundamental theorem of asset pricing in discrete time for finite spaces, American put, Snell envelope, stopping time, optimal stopping, stochastic integration, stochastic differential equations and Ito calculus, Black-Merton-Scholes model.

**Intended learning outcomes**

The student is acquainted with advanced results in financial mathematics. He/She gains the ability to work on contemporary research questions in financial mathematics and can apply his/her skills to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

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<td>1 semester</td>
<td>graduate</td>
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**Contents**

Finite permutation groups and character theory of finite groups, interrelations and special techniques such as the S-rings of Schur.

**Intended learning outcomes**

The student masters advanced algebraic concepts and methods. He/She gains the ability to work on contemporary research questions in group theory and representation theory and can apply his/her skills to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<tr>
<td>Geometrical Mechanics</td>
<td>10-M=VGEM-161-m01</td>
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**Module coordinator**  
Dean of Studies Mathematik (Mathematics)

**Module offered by**  
Institute of Mathematics

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**Contents**

The module builds on the topics covered in module 10-M=ADGM and discusses these in more detail: symplectic geometry, cotangent bundles and other examples of symplectic manifolds, symmetries and Noether theorem, phase space reduction, normal forms, introduction to Poisson geometry.

**Intended learning outcomes**

The student is acquainted with selected advanced applications of differential geometry to geometric mechanics. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and questions in physics.

**Courses**  
(type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)  
Module taught in: German and/or English

**Method of assessment**  
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

creditable for bonus

**Allocation of places**  
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**Additional information**  
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**Referred to in LPO I**  
(examination regulations for teaching-degree programmes)

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Module title: Industrial Statistics 2
Abbreviation: 10-M=VIST-161-m01

Module coordinator: Dean of Studies Mathematik (Mathematics)
Module offered by: Institute of Mathematics

ECTS: 10
Method of grading: numerical grade
Only after succ. compl. of module(s)

Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
Linear models, regression analysis, nonlinear regression, experimental design, basics in time series modeling, basics in empirical time series analysis, methods of exponential smoothing, predictions and prediction domains, statistical process monitoring.

Intended learning outcomes:
The student masters advanced statistical methods for industrial applications.

Courses:
(type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)
Module taught in: German and/or English

Method of assessment:
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English
creditable for bonus

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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### Module Arithmetics

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<td>Field Arithmetics</td>
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**Module coordinator**
Dean of Studies Mathematik (Mathematics)

**Module offered by**
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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
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### Contents

Combination of Galois theory, group theory and the theory of function fields with the aim of application in number theory, e.g. topics around Hilbert's irreducibility theorem, permutation polynomials (e.g. Calitz-Wan-conjecture) and the inverse problem in Galois theory.

### Intended learning outcomes

The student masters advanced algebraic concepts and methods. He/She gains the ability to work on contemporary research questions in algebra and can apply his/her skills to complex problems.

### Courses (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

creditable for bonus

### Allocation of places

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### Additional information

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<td>Numeric of Partial Differential Equations</td>
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**Contents**

Types of partial differential equations, qualitative properties, finite differences, finite elements, error estimates (numerical methods for elliptic, parabolic and hyperbolic partial differential equations; finite elements method, discontinuous Gelerkin finite elements method, finite differences and finite volume methods).

**Intended learning outcomes**

The student is acquainted with advanced methods for discretising partial differential equations.

**Courses** (type, number of weekly contact hours, language — if other than German)

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Language of assessment: German or English
creditable for bonus

**Allocation of places**

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**Additional information**

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<td>Selected Topics in Optimization</td>
<td>10-M=VOPT-161-m01</td>
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**Contents**

Selected topics in optimization, e.g. inner point methods, semidefinite programs, non-smooth optimization, game theory, optimization with differential equations.

**Intended learning outcomes**

The student is acquainted with advanced methods in continuous optimization. He gains the ability to work on contemporary research questions in continuous optimization.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

creditable for bonus

**Allocation of places**

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**Additional information**

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<td>Statistical Analysis</td>
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**Module coordinator**
Dean of Studies Mathematik (Mathematics)

**Module offered by**
Institute of Mathematics

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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
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**Contents**
Contingency tables, categorical regression, one-factorial variance analysis, two-factorial variance analysis, discriminant function analysis, cluster analysis, principal component analysis, factor analysis.

**Intended learning outcomes**
The student is acquainted with the fundamental methods in statistical analysis and can apply them to practical problems.

**Courses**
(type, number of weekly contact hours, language — if other than German)

V 4) + Ü (2)

Module taught in: German and/or English

**Method of assessment**
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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)

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**Module title** | **Abbreviation**  
--- | ---  
Insurance Mathematics 2 | 10-M=VVSM-161-m01  

**Module coordinator** | **Module offered by**  
--- | ---  
Dean of Studies Mathematik (Mathematics) | Institute of Mathematics  

| ECTS | Method of grading | Only after succ. compl. of module(s) |  
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10 | numerical grade | -- |  

| Duration | Module level | Other prerequisites |  
--- | --- | --- |  
1 semester | graduate | -- |  

**Contents**

This module discusses modern valuation approaches and multiple decrement models regarding one life or two lives: modern valuation in life insurance mathematics, axiomatic derivation of the product measure approach, Markov chain models, Kolmogorov's differential equations, Thiele's differential equations, numerical applications, joint life policies.

**Intended learning outcomes**

The student is acquainted with advanced methods in insurance mathematics. He gains the ability to work on contemporary research questions in insurance mathematics and can apply his/her skills to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)  
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester  
Language of assessment: German or English  
creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Module coordinator**  
Dean of Studies Mathematik (Mathematics)

**Module offered by**  
Institute of Mathematics

**ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** |
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10        | numerical grade       | --                                       |

**Duration** | **Module level** | **Other prerequisites** |
-------------|------------------|-------------------------|
1 semester   | graduate         | --                      |

### Contents

State-space models, Kalman filter, frequency spaces, Fourier analysis, periodograms, characterisation of autocovariance functions.

### Intended learning outcomes

The student is acquainted with advanced methods in time series analysis. He gains the ability to work on contemporary research questions in this field.

### Courses (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)  
Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester  
Language of assessment: German or English  
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### Allocation of places

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**Contents**

Advanced methods and results in a selected field of discrete mathematics (e.g. coding theory, cryptography, graph theory or combinatorics)

**Intended learning outcomes**

The student is acquainted with advanced results in a selected topic in discrete mathematics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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### Contents

Fundamentals of dynamical systems, e.g. stability theory, ergodic theory, Hamiltonian systems.

### Intended learning outcomes

The student masters the mathematical methods in the theory of dynamic systems, and is able to analyse their quality.

### Courses (type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)

Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

Creditable for bonus

### Allocation of places

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### Additional information

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<td>Aspects of Geometry</td>
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**Contents**

In-depth discussion of a special type of geometry taking into account recent developments and interrelations with other mathematical structures, e.g. topological geometries, diagram geometries.

**Intended learning outcomes**

The student is acquainted with advanced results in a selected field of geometry and can apply his/her skills to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title
Mathematical Continuum Mechanics

Abbreviation
10-M=VKOM-161-m01

Module coordinator
Dean of Studies Mathematik (Mathematics)

Module offered by
Institute of Mathematics

ECTS
5

Method of grading
Numerical grade

Only after succ. compl. of module(s)

Duration
1 semester

Module level
Graduate

Other prerequisites
--

Contents
Partial differential equations and/or variational methods in the context of continuum mechanics.

Intended learning outcomes
The student masters the mathematical methods in mathematical continuum mechanics and knows about their main fields of application.

Courses (type, number of weekly contact hours, language — if other than German)
V (3) + Ü (1)

Module taught in: German and/or English

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Language of assessment: German or English

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**Contents**

Mathematical fundamentals of image processing and computer vision such as elementary projective geometry, camera models and camera calibration, rigid and non-rigid registration, reconstruction of 3D objects from camera pictures; algorithms; module might also include an introduction to geometric methods and tomography.

**Intended learning outcomes**

The student masters the mathematical methods in the theory of image processing and knows about their main fields of application.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 60 to 90 minutes, usually chosen) or b) oral examination of one candidate each (approx. 15 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title
Selected Topics in Mathematical Physics

### Abbreviation
10-M=VMPH-161-m01

### Module coordinator
Dean of Studies Mathematik (Mathematics)

### Module offered by
Institute of Mathematics

### ECTS
10

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
graduate

### Other prerequisites
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### Contents
Selected topics in mathematical physics, for example continuum mechanics, fluid dynamics, mathematical material sciences, geometric field theory, advanced topics in quantum theory.

### Intended learning outcomes
The student is acquainted with an advanced topic in mathematical physics. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and questions in physics.

### Courses
(type, number of weekly contact hours, language — if other than German)

- V (4) + Ü (2)

Module taught in: German and/or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 90 to 120 minutes, usually chosen) or
- b) oral examination of one candidate each (approx. 20 minutes) or
- c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English
creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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### Contents

Selected topics in linear and non-linear control theory, e.g. networked linear control systems, controllability of bilinear systems.

### Intended learning outcomes

The student gains insight into contemporary research problems in control theory. He/She masters advanced techniques in this field and can apply them to complex problems.

### Courses (type, number of weekly contact hours, language — if other than German)

- V (4) + Ü (2)

Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

Creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Inverse Problems

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### Contents

Linear operator equations, ill-posed problems, regularisation theory, Tikhonov regularisation, iterative regularisation methods, examples of ill-posed problems.

### Intended learning outcomes

The student can judge whether a given problem is well posed or ill posed. He/She can apply regularisation methods and examine them regarding stability and convergence, and is familiar with selected inverse problems.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)

Module taught in: German and/or English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 60 to 90 minutes, usually chosen) or b) oral examination of one candidate each (approx. 15 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

### Allocation of places

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### Additional information

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### Referred to in LPO 1 (examination regulations for teaching-degree programmes)

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**Contents**
Basics in module theory: modules and module spaces, canonical decomposition and representations, simple, semi-simple and complex modules, module trees and their defibrations, distorsion theorems, reduction theorems.

**Intended learning outcomes**
The student masters mathematical methods in module theory and is able to analyse their quality.

**Courses**
(type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)
Module taught in: German and/or English

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 60 to 90 minutes, usually chosen) or
- b) oral examination of one candidate each (approx. 15 minutes) or
- c) oral examination in groups (groups of 2, approx. 10 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English
creditable for bonus

**Allocation of places**
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**Additional information**
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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)
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Module title | Abbreviation
---|---
Non-linear Analysis | 10-M=VNAN-161-m01

Module coordinator | Module offered by
Dean of Studies Mathematik (Mathematics) | Institute of Mathematics

ECTS | Method of grading | Only after succ. compl. of module(s)
---|---|---
5 | numerical grade | --

Duration | Module level | Other prerequisites
---|---|---
1 semester | graduate | --

Contents
Methods in nonlinear analysis (e.g. topological methods, monotony and variational methods) with applications.

Intended learning outcomes
The student is acquainted with the concepts of non-linear analysis, can compare them and assess their applicability on practical problems.

Courses (type, number of weekly contact hours, language — if other than German)
V (3) + Ü (1)
Module taught in: German and/or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English

Allocation of places
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Additional information
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### Contents
Basics in optimal control of ordinary and partial differential equations, theory of optimal control, conditions for optimality, methods for numerical solution.

### Intended learning outcomes
The student is acquainted with advanced methods in optimal control. He gains the ability to work on contemporary research questions in continuous optimization.

### Courses (type, number of weekly contact hours, language — if other than German)
V (3) + Ü (1)
Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 60 to 90 minutes, usually chosen) or b) oral examination of one candidate each (approx. 15 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English
creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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## Networked Systems

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### Module coordinator
Dean of Studies Mathematik (Mathematics)

### Module offered by
Institute of Mathematics

### ECTS | Method of grading | Only after succ. compl. of module(s) |
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### Contents
Contemporary topics in networked linear and non-linear dynamical systems (homogenous and non-homogenous systems); analysis of control-theoretical aspects (controllability, accessibility, etc.).

### Intended learning outcomes
The student is acquainted with advanced methods in the field of networked systems. He gains the ability to work on contemporary research questions in networked systems.

### Courses (type, number of weekly contact hours, language — if other than German)
V (3) + Ü (1)

Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 60 to 90 minutes, usually chosen) or b) oral examination of one candidate each (approx. 15 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Complex Geometry

**Module title**: Complex Geometry

**Abbreviation**: 10-M=VKGE-161-m01

**Module coordinator**: Dean of Studies Mathematik (Mathematics)

**Module offered by**: Institute of Mathematics

**ECTS**: 10

**Method of grading**: numerical grade

**Only after succ. compl. of module(s)**: --

**Duration**: 1 semester

**Module level**: graduate

**Other prerequisites**: --

#### Contents

The module builds on the topics covered in module 10-M=ADGM and discusses these in more detail: Wirtinger calculus, complex structures and complex manifolds, metrics on complex manifolds (e.g. conformal, hermitian, Kähler), differential operators on complex manifolds, classification of complex manifolds.

#### Intended learning outcomes

The student knows and masters advanced methods and notions in complex differential geometry. He is familiar with the central concepts in this field and is able to apply the fundamental proof methods independently.

#### Courses (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

#### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

Creditable for bonus: --

#### Allocation of places

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#### Additional information

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#### Referred to in LPO I (examination regulations for teaching-degree programmes)

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**Contents**

Elliptic, parabolic, and hyperbolic equations; Laplace equation, heat equation and wave equation as standard examples; initial and boundary value problems; well-posed and ill-posed problems; solution methods; extensions and generalisations; Hilbert space methods; Sobolev spaces and Fourier transforms.

**Intended learning outcomes**

The student is acquainted with fundamental concepts and solution methods in the theory of partial differential equations, as well as standard examples from mathematical physics. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and questions in physics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English
creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title
Pseudo Riemannian and Riemannian Geometry

### Abbreviation
10-M=VPRG-161-m01

### Module coordinator
Dean of Studies Mathematik (Mathematics)

### Module offered by
Institute of Mathematics

### ECTS
10

### Method of grading
numerical grade --

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

## Contents
The module builds on the topics covered in module 10-M=ADGM and discusses these in more detail: Riemannian and pseudo-Riemannian manifolds, Levi-Civita connection and curvature, geodesics and the exponential map, Jacobi fields, comparison theorems in Riemannian geometry, submanifolds, integration, d'Alembert and Laplace operators, causal structure of Lorenz manifolds, Einstein equations and applications in general relativity theory.

## Intended learning outcomes
The student is acquainted with advanced topics in differential geometry on Riemannian and pseudo-Riemannian manifolds. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and questions in physics.

## Courses
(type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)
Module taught in: German and/or English

## Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English creditable for bonus

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**Contents**
Banach and Hilbert spaces, bounded operators, principles of functional analysis, further contemporary topics in functional analysis and applications to other fields of mathematics.

**Intended learning outcomes**
The student is acquainted with fundamental concepts and methods in a contemporary field of functional analysis, and is able to apply these skills to complex questions.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English creditable for bonus

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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### Module title
Applied Differential Geometry

### Abbreviation
10-M=VADG-161-m01

### Module coordinator
Dean of Studies Mathematik (Mathematics)

### Module offered by
Institute of Mathematics

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### Contents
The module builds on the topics covered in module 10-M=ADGM and discusses selected applications of differential geometry, e.g. at the interface of control theory and mechanics (subriemannian geometry), in the smooth optimisation on manifolds or applications in physics.

### Intended learning outcomes
The student is acquainted with selected advanced applications of differential geometry. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and questions in physics.

### Courses
(type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Module title
Analysis and Geometry of Classical Systems

### Abbreviation
10-M=MP1-161-m01

### Module coordinator
Dean of Studies Mathematik (Mathematics)

### Module offered by
Institute of Mathematics

### ECTS
10

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

### Contents
Modern analytic methods (such as partial differential equations) and geometric methods (such as differential geometry) for the description of classical physics. Examples include movements of deformable bodies as reaction to outer load (deformation of elastic bodies, flow of a fluid, stream of a gas). Additional examples include geometric mechanics and symplectic geometry, classical field theory and classical gauge theory, general relativity theory.

### Intended learning outcomes
The student gains insight into modern methods in mathematics, which are applied in classical physics. He/She masters advanced techniques in this field and is able to apply them to complex problems.

### Courses (type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)

Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)

Language of assessment: German or English
creditable for bonus

### Allocation of places
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### Additional information
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</table>

**Contents**

Modern algebraic methods for dynamics of quantum systems, e. g. operator algebras with applications in algebraic quantum field theory, spectral theory, symmetries and representation theory.

**Intended learning outcomes**

The student gains insight into modern methods in mathematics, which are applied in quantum physics. He/She masters advanced techniques in this field and is able to apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

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<tr>
<th>Type</th>
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<th>Language</th>
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Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)

Language of assessment: German or English creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Research in Groups - Algebra</td>
<td>10-M=GALG-161-m01</td>
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</table>

**Contents**

Selected modern topics in algebra (e.g. ring theory, commutative algebra, differential algebra, local fields, computer algebra, algebras, division rings, quadratic forms).

**Intended learning outcomes**

The student gains insight into contemporary research problems in algebra. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk (60 to 120 minutes)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Research in Groups - Discrete Mathematics</td>
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**Contents**

Selected modern topics in discrete mathematics.

**Intended learning outcomes**

The student gains insight into contemporary research problems in discrete mathematics. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk (60 to 120 minutes)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Research in Groups - Dynamical Systems and Control Theory</td>
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**Contents**

Selected modern topics in dynamical systems and control theory.

**Intended learning outcomes**

The student gains insight into contemporary research problems in dynamical systems and control theory. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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**Allocation of places**

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<td>Research in Groups - Complex Analysis</td>
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**Contents**

Selected modern topics in complex analysis (e.g. in approximation theory, potential theory, complex dynamics, geometric complex analysis, value distribution theory).

**Intended learning outcomes**

The student gains insight into contemporary research problems in complex analysis. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Talk (60 to 120 minutes)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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<td>Research in Groups - Geometry and Topology</td>
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### Contents

Selected modern topics in geometry and topology.

### Intended learning outcomes

The student gains insight into contemporary research problems in geometry and topology. He/She masters advanced techniques in this field and can apply them to complex problems.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)

Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- talk (60 to 120 minutes)
- Assessment offered: In the semester in which the course is offered and in the subsequent semester
- Language of assessment: German or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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## Module title
Research in Groups - Mathematics in Context

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## Module coordinator
Dean of Studies Mathematik (Mathematics)

## Module offered by
Institute of Mathematics

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## Duration
1 semester

## Module level
graduate

## Other prerequisites
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## Contents
Reflection on mathematics in a cultural context, for example by discussing part of the history of mathematics, given by a historical period, a geographic region or a particular field of mathematics. Other possibilities arise from the connection of mathematics with literature, language, music, art or the media.

## Intended learning outcomes
The student realises the cultural dimension of mathematics and its relation to other cultural fields.

## Courses
V (2) + S (2)
Module taught in: German and/or English

## Method of assessment
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## Allocation of places
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## Additional information
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<td>Research in Groups - Mathematics in the Sciences</td>
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**Contents**

A modern topic in mathematics in the sciences.

**Intended learning outcomes**

The student gains insight into contemporary research problems in mathematics in the sciences. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Talk (60 to 120 minutes)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Research in Groups - Measure and Integral</td>
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**Contents**

Aspects of measure and integration theory: sigma algebras and Borel sets, volume and measure, measurable functions and Lebesgue integrals, selected applications, e.g. product measures (with Fubini's theorem and the transformation rule), Lp spaces and absolute continuity, measures on topological spaces.

**Intended learning outcomes**

The student gains insight into contemporary research problems in measure and integration theory. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Talk (60 to 120 minutes)
Assessment offered: In the semester in which the course is offered and in the subsequent semester Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title
Research in Groups - Numerical Mathematics and Applied Analysis

### Abbreviation
10-M=GNMA-161-m01

### Module coordinator
Dean of Studies Mathematik (Mathematics)

### Module offered by
Institute of Mathematics

### ECTS
10

### Method of grading
Numerical grade

### Only after succ. compl. of module(s)
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### Duration
1 semester

### Module level
Graduate

### Other prerequisites
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### Contents
Selected topics in numerical mathematics, applied analysis or scientific computing.

### Intended learning outcomes
The student gains insight into a contemporary research problems in numerical mathematics or applied analysis. He/She masters advanced techniques in this field and can apply them to complex problems.

### Courses (type, number of weekly contact hours, language — if other than German)

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### Module taught in
German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

**Talk (60 to 120 minutes)**

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

### Allocation of places
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### Additional information
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<td>Research in Groups - Robotics, Optimization and Control Theory</td>
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**Contents**

Selected modern topics in robotics, optimisation and control theory.

**Intended learning outcomes**

The student gains insight into contemporary research problems in robotics, optimization and control theory. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk (60 to 120 minutes)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Research in Groups -Time Series Analysis</td>
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**Contents**

Selected modern topics in time series analysis.

**Intended learning outcomes**

The student gains insight into contemporary research problems in time series analysis. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk (60 to 120 minutes)

Assessment offered: In the semester in which the course is offered and in the subsequent semester Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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## Module title
Research in Groups - Statistics

### Abbreviation
10-M=GSTA-161-m01

### Module coordinator
Dean of Studies Mathematik (Mathematics)

### Module offered by
Institute of Mathematics

### ECTS
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### Contents
Selected modern topics in statistics.

### Intended learning outcomes
The student gains insight into contemporary research problems in statistics. He/She masters advanced techniques in this field and can apply them to complex problems.

### Courses (type, number of weekly contact hours, language — if other than German)
V (2) + S (2)
Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
talk (60 to 120 minutes)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Research in Groups - Number Theory</td>
<td>10-M=GNTH-161-m01</td>
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<tbody>
<tr>
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## Contents

Selected modern topics in number theory (e.g. algebraic number theory, modular forms, diophantine analysis).

## Intended learning outcomes

The student gains insight into contemporary research problems in number theory. He/She masters advanced techniques in this field and can apply them to complex problems.

## Courses

(type, number of weekly contact hours, language — if other than German)

V (2) + S (2)

Module taught in: German and/or English

## Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk (60 to 120 minutes)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

## Allocation of places

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## Additional information

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**Contents**

Selected modern topics in control theory of quantum mechanical systems.

**Intended learning outcomes**

The student gains insight into contemporary research problems in control theory of quantum mechanical systems. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk (60 to 120 minutes)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English

**Allocation of places**

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**Additional information**

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<td>Research in Groups - Differential Geometry</td>
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**Module coordinator**
Dean of Studies Mathematik (Mathematics)

**Module offered by**
Institute of Mathematics

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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
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**Contents**
Selected modern topics in differential geometry.

**Intended learning outcomes**
The student gains insight into contemporary research problems in Differential Geometry. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (2) + S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
talk (60 to 120 minutes)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English

**Allocation of places**
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**Additional information**
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**Contents**
Selected modern topics in deformation quantization.

**Intended learning outcomes**
The student gains insight into contemporary research problems in Deformation Quantization. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (2) + S (2)  
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
talk (60 to 120 minutes)  
Assessment offered: In the semester in which the course is offered and in the subsequent semester  
Language of assessment: German or English

**Allocation of places**
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**Additional information**
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**Contents**
Selected modern topics in non-linear analysis.

**Intended learning outcomes**
The student gains insight into contemporary research problems in Non-linear Analysis. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses (type, number of weekly contact hours, language — if other than German)**
V (2) + S (2)
Module taught in: German and/or English

**Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)**
talk (60 to 120 minutes)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English

**Allocation of places**
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**Additional information**
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**Contents**

Selected modern topics in operator algebras.

**Intended learning outcomes**

The student gains insight into contemporary research problems in Operator algebras. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

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<th>V (2) + S (2)</th>
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Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- talk (60 to 120 minutes)
- Assessment offered: In the semester in which the course is offered and in the subsequent semester
- Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title
Seminar in Applied Differential Geometry

### Abbreviation
10-M=SADG-161-m01

### Module coordinator
Dean of Studies Mathematik (Mathematics)

### Module offered by
Institute of Mathematics

### ECTS
5

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
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### Duration
1 semester

### Module level
graduate

### Other prerequisites
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### Contents
A modern topic in applied differential geometry.

### Intended learning outcomes
The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

### Courses
(type, number of weekly contact hours, language — if other than German)

- S (2)
  - Module taught in: German and/or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- talk (60 to 120 minutes)
  - Assessment offered: In the semester in which the course is offered and in the subsequent semester
  - Language of assessment: German or English

### Allocation of places
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### Additional information
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**Contents**

A modern topic in algebra.

**Intended learning outcomes**

The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Talk (60 to 120 minutes)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Contents**

A modern topic in dynamical systems and control.

**Intended learning outcomes**

The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk (60 to 120 minutes)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English

**Allocation of places**

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**Contents**

A modern topic in complex analysis.

**Intended learning outcomes**

The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk (60 to 120 minutes)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**

A modern topic in financial and insurance mathematics.

**Intended learning outcomes**

The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Talk (60 to 120 minutes)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**

A modern topic in geometry and topology.

**Intended learning outcomes**

The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Talk (60 to 120 minutes)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Module coordinator**
Dean of Studies Mathematik (Mathematics)

**Module offered by**
Institute of Mathematics

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**Contents**
A modern topic in mathematics with interdisciplinary aspects.

**Intended learning outcomes**
The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)
S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- **talk** (60 to 120 minutes)
- Assessment offered: In the semester in which the course is offered and in the subsequent semester
- Language of assessment: German or English

**Allocation of places**
--

**Additional information**
--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)
--
### Module title
Seminar Mathematics in the Sciences

### Abbreviation
10-M=SMSC-161-m01

### Module coordinator
Dean of Studies Mathematik (Mathematics)

### Module offered by
Institute of Mathematics

### ECTS
<table>
<thead>
<tr>
<th>Duration</th>
<th>Module level</th>
<th>Other prerequisites</th>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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### Method of grading
numerical grade --

### Only after succ. compl. of module(s)

### Contents
A modern topic in mathematics in the sciences.

### Intended learning outcomes
The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

### Courses
(type, number of weekly contact hours, language — if other than German)

S (2)
Module taught in: German and/or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Talk (60 to 120 minutes)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English

### Allocation of places
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### Additional information
--

### Referred to in LPO I
(examination regulations for teaching-degree programmes)
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<table>
<thead>
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<th>Module title</th>
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<tbody>
<tr>
<td>Seminar in Numerical Mathematics and Applied Analysis</td>
<td>10-M=SNMA-161-m01</td>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
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**Contents**

A modern topic in numerical mathematics or applied analysis.

**Intended learning outcomes**

The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Talk (60 to 120 minutes)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
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<td>Seminar in Optimization</td>
<td>10-M=SOPT-161-m01</td>
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**Contents**

A modern topic in optimisation.

**Intended learning outcomes**

The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

| S (2) | Module taught in: German and/or English |

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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<th>talk (60 to 120 minutes)</th>
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**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Seminar in Statistics</td>
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<td>1 semester</td>
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**Contents**

A modern topic in statistics.

**Intended learning outcomes**

The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Talk (60 to 120 minutes)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<th>Module title</th>
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<td>Seminar in Non-linear Analysis</td>
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**Module coordinator**
Dean of Studies Mathematik (Mathematics)

**Module offered by**
Institute of Mathematics

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</table>

**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
--

**Contents**
A modern topic in non-linear analysis.

**Intended learning outcomes**
The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

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**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk (60 to 120 minutes)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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<td>Laser Spectroscopy</td>
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<td>lecturer of seminar &quot;Laserspektroskopie&quot; (Laser Spectroscopy)</td>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</table>

**Contents**

German contents available but not translated yet.

Das Modul führt in die Grundlagen der Laserspektroskopie ein. Als experimentelle Methoden werden die Absorptions- und Emissionsspektroskopie behandelt.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Die Studierenden sind in der Lage, Aufbau und Funktionsweise eines Lasers sowie die optischen Grundlagen zu erklären. Er/Sie kann das Prinzip der Absorptions- und Emissionsspektroskopie darstellen.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Advanced Physical Chemistry (Lab)</td>
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<tbody>
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<td>lecturer of seminar &quot;Laserspektroskopie&quot; (Laser Spectroscopy)</td>
<td>Institute of Physical and Theoretical Chemistry</td>
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<tbody>
<tr>
<td></td>
<td>graduate</td>
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</table>

**Contents**

German contents available but not translated yet.


**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Die Studierenden können moderne experimentelle Methoden der Physikalischen Chemie sicher praktisch durchführen. Er/Sie kann erhaltene Messwerte inhaltlich und graphisch mit geeigneten Computerprogrammen sowie rechnerisch analysieren und in einem wissenschaftlichen Protokoll formulieren.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (4)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Vortestate/Nachtestate (pre and post-experiment examination talks approx. 15 minutes each, log approx. 5 to 10 pages each) and assessment of practical performance (2 to 4 random examinations)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th><strong>Module title</strong></th>
<th><strong>Abbreviation</strong></th>
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<tbody>
<tr>
<td>Statistical Mechanics and Reaction Dynamics</td>
<td>08-PCM2-161-m01</td>
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</table>

**Module coordinator**  
lecturer of seminar "Chemische Dynamik" (Chemical Dynamics)

**Module offered by**  
Institute of Physical and Theoretical Chemistry

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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</table>

**Contents**

The module deals with selected contents of statistical mechanics and reaction dynamics. It introduces the basic principles of statistical thermodynamics and conveys the transition state theory. Other topics are uni- and bimolecular reactions as well as charge and energy transfer.

**Intended learning outcomes**

The students are familiar with selected contents of statistical mechanics and reaction dynamics. They know the basic principles of statistical thermodynamics and can apply them.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)  
Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) talk (approx. 30 minutes)  
Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title
Nanoscale Materials

### Abbreviation
08-PCM3-161-m01

### Module coordinator
lecturer of the seminar "Nanoskalige Materialien"

### Module offered by
Institute of Physical and Theoretical Chemistry

### ECTS
5

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

### Contents
German contents available but not translated yet.


### Intended learning outcomes
German intended learning outcomes available but not translated yet.

Die Studierenden sind in der Lage, nanoskalige Materialien zu charakterisieren. Er/Sie kann Analysenmethoden sowie Anwendungsgebiete nanoskaliger Materialien anführen.

### Courses
(type, number of weekly contact hours, language — if other than German)

<table>
<thead>
<tr>
<th>S (2) + Ü (1)</th>
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</thead>
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Module taught in: German or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- a) written examination (approx. 90 minutes) or
- b) oral examination of one candidate each (approx. 20 minutes) or
- c) talk (approx. 30 minutes)

Language of assessment: German and/or English creditable for bonus

### Allocation of places
--

### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Module title
Ultrafast spectroscopy and quantum-control

### Abbreviation
08-PCM4-161-m01

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<tbody>
<tr>
<td>lecturer of the seminar &quot;Nanoskalige Materialien&quot;</td>
<td>Institute of Physical and Theoretical Chemistry</td>
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<tr>
<td>1 semester</td>
<td>graduate</td>
<td>Prior completion of modules 08-PCM1a and 08-PCM1b recommended.</td>
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</table>

### Contents
German contents available but not translated yet.

Das Modul behandelt spezielle Themen der Ultrakurzzeitspektroskopie und Quantenkontrolle. Schwerpunkte sind ultrakurze Laserimpulse, zeitaufgelöste Laserspektroskopie sowie kohärente Kontrolle.

### Intended learning outcomes
German intended learning outcomes available but not translated yet.


### Courses
(type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)

Module taught in: German or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) talk (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places
--

### Additional information
--

### Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Module title
Physical chemistry of supramolecular assemblies

### Abbreviation
08-PCM5-161-m01

### Module coordinator
lecturer of the seminar "Physikalische Chemie Supramolekularer Strukturen"

### Module offered by
Institute of Physical and Theoretical Chemistry

### ECTS
5

### Method of grading
Only after succ. compl. of module(s)

### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

### Contents
German contents available but not translated yet.

Das Modul betrachtet im Detail die grundlegenden Wechselwirkungen zwischen Molekülen. Es werden Bildung und physikalische-chemische Eigenschaften von Aggregaten besprochen. Wichtige Anwendungen supramolekularer Chemie werden thematisiert.

### Intended learning outcomes
German intended learning outcomes available but not translated yet.


### Courses
(type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)

Module taught in: German or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) talk (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

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<table>
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<tr>
<td>Physical Chemistry (Advanced Lab)</td>
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**Module coordinator**

lecturers Physikalische Chemie (Physical Chemistry)

**Module offered by**

Institute of Physical and Theoretical Chemistry

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**Duration**

graduate: --

**Contents**

German contents available but not translated yet.

Das Modul bietet den Studierenden die Möglichkeit, in einem Arbeitskreis des Instituts für Physikalische Chemie mit zu arbeiten sowie spezifische Synthese- und Analysemethoden kennen zu lernen.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Die Studierenden können für einen Arbeitskreis der Physikalischen Chemie typische Untersuchungsmethoden anwenden sowie die erhaltenen Ergebnisse analysieren um aktuelle Fragestellungen der Physikalischen Chemie zu beantworten.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (4)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

presentation (approx. 20 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<tr>
<td>Basics and applications of quantum chemistry</td>
<td>08-TCM2-161-m01</td>
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**Module coordinator**

lecturer of lecture "Computational Chemistry"

**Module offered by**

Institute of Physical and Theoretical Chemistry

**ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** |
--- | --- | --- |
5 | numerical grade | -- |

**Duration** | **Module level** | **Other prerequisites** |
--- | --- | --- |
1 semester | graduate | -- |

**Contents**

The module introduces students to computational chemistry.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Die Studierenden sind in der Lage, die theoretischen Grundlagen der Computational Chemistry zu erklären sowie Methoden der Computational Chemistry anzuwenden.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
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<td>Numerical Methods and Programing</td>
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<td>lecturer of lecture &quot;Programmieren in Theoretischer Chemie&quot;</td>
<td>Institute of Physical and Theoretical Chemistry</td>
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<tbody>
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<td>1 semester</td>
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</table>

### Contents

German contents available but not translated yet.

Das Modul führt in Grundlagen der Programmierung in der Theoretischen Chemie ein und zeigt Anwendungsgebiete auf.

### Intended learning outcomes

German intended learning outcomes available but not translated yet.

Die Studierenden können eine in der Theoretischen Chemie verwendete Programmiersprache theoretisch erklären und praktisch anwenden sowie Anwendungsmöglichkeiten anführen.

### Courses (type, number of weekly contact hours, language — if other than German)

S (2) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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<td>Quantum Dynamics</td>
<td>08-TCM4-161-m01</td>
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</table>

**Contents**

Time-dependent Schrödinger equation, propagators, time-dependent perturbation theory, adiabatic theorem, diabatic and adiabatic states, non-adiabatic dynamics, mixed quantum-classical dynamics.

**Intended learning outcomes**

The students possess knowledge about the time-dependent description of the nuclear and electronic dynamics in molecules. Their insight into the methods and the numerical realizations allow them to carry out applications in the field of theoretical chemistry.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>graduate</td>
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</table>

**Contents**

The module introduces students to theoretical chemistry.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Die Studierenden können mathematische und physikalische Grundlagen quantenchemischer und quantendynamischer Ansätze der Theoretischen Chemie darstellen.

**Courses (type, number of weekly contact hours, language — if other than German)**

S (2) + Ü (2)

**Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)**

a) written examination (approx. 90 to 180 minutes)  
b) oral examination of one candidate each (20 to 30 minutes)  
c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate)  
d) log (approx. 20 pages)  
e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I (examination regulations for teaching-degree programmes)**

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## Subdivided Module Catalogue for the Subject

**MINT Teacher Education PLUS, Elite Network Bavaria (ENB)**

120 ECTS credits

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<thead>
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<td>Institute of Physical and Theoretical Chemistry</td>
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### Contents

The module offers students the opportunity to work in a group of the Institute for Theoretical Chemistry as well as to become familiar with typical working methods. The main focus of the practical course is Quantum Chemistry.

### Intended learning outcomes

The students are able to apply typical working methods of the Theoretical Chemistry, especially in the area of Quantum Chemistry. He/She can explain specific contents of Quantum Chemistry.

### Courses (type, number of weekly contact hours, language — if other than German)

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### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- Presentation (approx. 30 minutes)
- Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

--
### Module title
Theoretical Chemistry - Project course quantum dynamics

### Abbreviation
08-TCAP2-161-m01

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#### Contents
The module offers students the opportunity to work in a group of the Institute for Theoretical Chemistry as well as to become familiar with typical working methods. The main focus of the practical course is Quantum Dynamics.

**Intended learning outcomes**
The students are able to apply typical working methods of the Theoretical Chemistry, especially in the area of Quantum Dynamics. He/She can explain specific contents of Quantum Dynamics.

**Courses** (type, number of weekly contact hours, language — if other than German)
P (5)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- Presentation (approx. 30 minutes)
- Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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Module title
Algorithms for Geographic Information Systems

Abbreviation
10-I=AGIS-161-m01

Module coordinator
holder of the Chair of Computer Science I

Module offered by
Institute of Computer Science

ECTS
5

Method of grading
numerical grade

Only after succ. compl. of module(s)
--

Duration
1 semester

Module level
graduate

Other prerequisites
--

Contents
Algorithmic foundations of geographic information systems and their application in selected problems of acquisition, processing, analysis and presentation of spatial information. Processes of discrete and continuous optimisation. Applications such as the creation of digital height models, working with GPS trajectories, tasks of spatial planning as well as cartographic generalisation.

Intended learning outcomes
The students are able to formalise algorithmic problems in the field of geographic information systems as well as to select and improve suitable approaches to solving these problems.

Courses
(type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English

Allocation of places
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Additional information
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<td>Computational Geometry</td>
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**Module coordinator**

holder of the Chair of Computer Science I

**Module offered by**

Institute of Computer Science

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</table>

**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

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### Contents

In many areas of computer science -- for example robotics, computer graphics, virtual reality and geographic information systems -- it is necessary to store, analyse, create or manipulate spatial data. This class is about the algorithmic aspects of these tasks: We will acquire techniques that are needed to plan and analyse geometric algorithms and data structures. Every technique will be illustrated with a problem in the practical areas listed above.

### Intended learning outcomes

The students are able to decide which algorithms or data structures are suitable for the solution of a given geometric problem. The students are able to analyse new problems and to come up with their own efficient solutions based on the concepts and techniques acquired in the lecture.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: German and/or English creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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Module title: Approximation Algorithms

Abbreviation: 10-I=APA-161-m01

Module coordinator: holder of the Chair of Computer Science I
Module offered by: Institute of Computer Science

ECTS: 5
Method of grading: numerical grade
Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents

The task of finding the optimal solution for a given problem is omnipresent in computer science. Unfortunately, there are many problems without an efficient algorithm for an optimal solution. As a result, in practice, methods are used which do not always give the optimal solution but always give good solutions. This lecture will discuss drafting and analysing techniques for algorithms which have a proven approximation quality. With the help of practical optimisation problems, the lecture will introduce students to important drafting techniques such as greedy, local search, scaling as well as methods based on linear programming.

Intended learning outcomes

The students are able to analyse easy approximation methods in terms of their quality. They understand fundamental drafting techniques such as greedy, local search and scaling as well as methods based on linear programming and are able to apply these to new problems.

Courses

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English
creditable for bonus

Allocation of places

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Additional information

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Referred to in LPO I

(examination regulations for teaching-degree programmes)

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Module title
Automata Theory

Abbreviation
10-I=AUT-161-m01

Module coordinator
Dean of Studies Informatik (Computer Science)

Module offered by
Institute of Computer Science

ECTS
5

Method of grading
numerical grade

Only after succ. compl. of module(s)

Duration
1 semester

Module level
graduate

Other prerequisites

Contents
Finite automata, regular languages, star-free languages, natural equivalence relations, predicate logic with words, language acceptance through monoids, syntactic monoid, predicate logical and algebraic characterisation of regular languages and star-free languages, two-way automata.

Intended learning outcomes
The students possess a fundamental and applicable knowledge in the areas of finite automata, regular languages, star-free languages, natural equivalence relations, predicate logic with words, language acceptance through monoids, syntactic monoid, predicate logical and algebraic characterisation of regular and star-free languages, two-way automata.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Language of assessment: German and/or English creditable for bonus

Allocation of places

Additional information

Referred to in LPO I (examination regulations for teaching-degree programmes)


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<td>Avionics Systems</td>
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<td>1 semester</td>
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</table>

**Contents**

The course *Avionik-Systeme (Avionics Systems)* offers an overview of software, hardware, sensors, actuators and communication of airplanes and satellites:
1. software module and the software structure
2. control
3. ground control
4. sensors and actuators
5. sensor fusion
6. reliability

**Intended learning outcomes**

At the end of the course, the students should be familiar with typical structures of avionic systems for satellites and airplanes. They should be able to design these. They should be able to program simple controls.

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**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English
creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Subdivided Module Catalogue for the Subject
MINT Teacher Education PLUS, Elite Network Bavaria (ENB)
, 120 ECTS credits

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</table>

Contents

Gödel numbering, computable functions, decidable and countable sets, halting problem, m-reducibility, creative and productive sets, relative computability, Turing reduction, countable degrees, arithmetic hierarchy.

Intended learning outcomes

The students possess a fundamental and applicable knowledge in the areas of Gödel numbers, countable functions, decidable and countable sets, halting problem, m-reducibility, creative and productive sets, relative computability, Turing reduction, countable degrees, arithmetic hierarchy.

Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Written examination (approx. 60 to 120 minutes).

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: German and/or English creditable for bonus

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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<table>
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<td>Compiler Construction</td>
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</table>

**Contents**

Lexical analysis, syntactic analysis, semantics, compiler generators, code generators, code optimisation.

**Intended learning outcomes**

The students possess knowledge in the formal description of programming languages and their compilation. They are able to perform transformations between them with the help of finite automata, push-down automata and compiler generators.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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## Module title
Deductive Databases

### Abbreviation
10-l=DDB-161-m01

### Module coordinator
Dean of Studies Informatik (Computer Science)

### Module offered by
Institute of Computer Science

### ECTS
8

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

### Contents
Syntax and semantics of logic programs; data structures, program structures and applications for Prolog; analytical methods for Datalog; negation and stratification; disjunctive logic programs.

### Intended learning outcomes
The students possess expertise in working with Prolog and Datalog (including negation and disjunction).

### Courses (type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

### Allocation of places
--

### Additional information
--

### Referred to in LPO 1 (examination regulations for teaching-degree programmes)
--
## Module title

**E-Learning**

### Abbreviation

10-I=EL-161-m01

## Module coordinator

holder of the Chair of Computer Science VI

## Module offered by

Institute of Computer Science

## ECTS

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## Method of grading

Only after successful completion of the module(s)

## Duration

1 semester

## Module level

graduate

## Other prerequisites

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## Contents

Learning paradigms, learning system types, author systems, learning platforms, standards for learning systems, intelligent tutoring systems, student models, didactics, problem-oriented learning and case-based training systems, adaptive tutoring systems, computer-supported cooperative learning, evaluation of learning systems.

## Intended learning outcomes

The students possess a theoretical and practical knowledge about eLearning and are able to assess possible applications.

## Courses

<table>
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<th>(type, number of weekly contact hours, language — if other than German)</th>
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## Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- **written examination (approx. 60 to 120 minutes).**
- **If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).**
- **Language of assessment: German and/or English creditable for bonus**

## Allocation of places

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## Additional information

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## Referred to in LPO I

(examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Embedded Systems</td>
<td>10-l=ES-161-m01</td>
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**Module coordinator**

holder of the Chair of Computer Science V

**Module offered by**

Institute of Computer Science

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<tr>
<td>1 semester</td>
<td>graduate</td>
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**Contents**

Models of embedded systems, implementation methods (ASIC, AISIP, micro controller), verification of embedded systems, implementation planning static, periodic and dynamic, binding problems, hardware synthesis, software synthesis.

**Intended learning outcomes**

The students are familiar with the technical possibilities for the design of embedded systems and master the most important techniques for the modelling, verification and optimisation of such systems in hardware and software.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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<td>Analysis and Design of Programs</td>
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</table>

**Contents**

Program analysis, model creation in software engineering, program quality, test of programs, process models.

**Intended learning outcomes**

The students are able to analyse programs, to use testing frameworks and metrics as well as to judge program quality.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Written examination (approx. 60 to 120 minutes).
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Language of assessment: German and/or English creditable for bonus.

**Allocation of places**

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**Additional information**

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<td>Information Retrieval</td>
<td>10-I=IR-161-m01</td>
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**Contents**

IR models (e.g. Boolean and vector space model, evaluation), processing of text (tokenising, text properties), data structures (e.g. inverted index), query elements (e.g. query operations, relevance feedback, query languages and paradigms, structured queries), search engine (e.g. architecture, crawling, interfaces, link analysis), methods to support IR (e.g. recommendation systems, text clustering and classification, information extraction).

**Intended learning outcomes**

The students possess theoretical and practical knowledge in the area of information retrieval and have acquired the technical know-how to create a search engine.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Written examination (approx. 60 to 120 minutes).
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Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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**Additional information**

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<td>Computational Complexity II</td>
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## Contents
Properties of NP-complete sets, autoreducibility, interactive proof systems, polynomial time hierarchy, complexity of probabilistic algorithms.

## Intended learning outcomes
The students possess a fundamental and applicable knowledge in the areas of properties of NP-complete sets, autoreducibility, interactive proof systems, polynomial time hierarchies, complexity of probabilistic algorithms.

## Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

## Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English
creditable for bonus

## Allocation of places
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## Additional information
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## Referred to in LPO I (examination regulations for teaching-degree programmes)
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Module title: Artificial Intelligence 1
Abbreviation: 10-I=KI1-161-m01

Module coordinator: holder of the Chair of Computer Science VI
Module offered by: Institute of Computer Science

ECTS: 5
Method of grading: numerical grade
Only after succ. compl. of module(s): --

Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents
Intelligent agents, uninformed and heuristic search, constraint problem solving, search with partial information, propositional and predicate logic and inference, knowledge representation.

Intended learning outcomes
The students possess theoretical and practical knowledge about artificial intelligence in the area of agents, search and logic and are able to assess possible applications.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Language of assessment: German and/or English creditable for bonus

Allocation of places
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Additional information
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### Contents
Planning, probabilistic closure and Bayesian networks, utility theory and decidability problems, learning from observations, knowledge while learning, neural networks and statistical learning methods, reinforcement learning, processing of natural language.

### Intended learning outcomes
The students possess theoretical and practical knowledge about artificial intelligence in the area of probabilistic closure, learning and language processing and are able to assess possible applications.

### Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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Module title: Performance Evaluation of Distributed Systems
Abbreviation: 10-I=LVS-161-m01

Module coordinator: holder of the Chair of Computer Science III
Module offered by: Institute of Computer Science

ECTS: 8
Method of grading: numerical grade
Only after succ. compl. of module(s): 

Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
Traffic theoretic models, fundamental concepts of theory of probability, transformation techniques, stochastic processes, methods for performance analysis of technical systems, queue-/traffic theory, analysis of Markov, non-Markov and time critical systems, matrix analytical method, practical examples for performance analysis of computer systems and networks: throughput and goodput analysis and other characteristics.

Intended learning outcomes:
The students possess the methodic knowledge and the practical skills necessary to model technical systems by means of the theory of probability and mathematical statistics.

Courses (type, number of weekly contact hours, language — if other than German):
V (4) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus):
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Language of assessment: German and/or English creditable for bonus

Allocation of places:
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Additional information:
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<td>Mathematical Logic</td>
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</table>

**Contents**

Propositional logic, first-order predicate logic, proof and deduction, Gödel’s completeness theorem, Tarski theorem, Gödel’s incompleteness theorem, undecidability and nonaxiomatisability of elemental arithmetic.

**Intended learning outcomes**

The students possess a fundamental and applicable knowledge in the areas of propositional logic, first-order predicate logic, proof and deduction, Gödel’s completeness theorem, Tarski theorem, Gödel’s incompleteness theorem, undecidability and nonaxiomatisability of elemental arithmetic.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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<td>Medical Informatics</td>
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**Contents**

Electronic patient folder, coding of medical data, hospital information systems, operation of computers in infirmary and functional units, medical decision making and assistance systems, statistics and data mining in medical research, case-based training systems in medical training.

**Intended learning outcomes**

The students possess theoretical and practical knowledge about the application of computer science methods in medicine.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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<td>Performance Engineering &amp; Benchmarking of Computer Systems</td>
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</table>

### Contents

Introduction to performance engineering of commercial software systems, performance measurement techniques, benchmarking of commercial software systems, modelling for performance prediction, case studies.

### Intended learning outcomes

The students possess a fundamental and applicable knowledge in the areas of performance metrics, measurement techniques, multi-factorial variance analysis, data analysis with R, benchmark approaches, modelling with queue networks, modelling methods, resource demand approximation, petri nets.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English creditable for bonus

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</table>

**Contents**

Spaces of numerical computation, raster and rounding, definition and implementation of computational arithmetic and interval calculation.

**Intended learning outcomes**

The students possess knowledge about the spaces of numerical computation, raster and roundings, definition and implementation of computational arithmetic and interval calculation. They master the application of algorithms.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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**Contents**

Introduction to simulation techniques, statistical groundwork, creation of random numbers and random variables, random sample theory and estimation techniques, statistical analysis of simulation values, inspection of measured data, planning and evaluation of simulation experiments, special random processes, possibilities and limits of model creation and simulation, advanced concepts and techniques, practical execution of simulation projects.

**Intended learning outcomes**

The students possess the methodic knowledge and the practical skills necessary for the stochastic simulation of (technical) systems, the evaluation of results and the correct assessment of the possibilities and limits of simulation methods.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).

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Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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**Additional information**

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Subdivided Module Catalogue for the Subject
MINT Teacher Education PLUS, Elite Network Bavaria (ENB)
, 120 ECTS credits

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<tr>
<td>1 semester</td>
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Contents

Current topics in the area of aerospace.

Intended learning outcomes

The students possess a fundamental and applicable knowledge about advanced topics in software engineering with a focus on modern software architectures and fundamental approaches to model-driven software engineering.

Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English
creditable for bonus

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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Module title: Visualization of Graphs
Abbreviation: 10-l=VG-161-m01

Module coordinator: holder of the Chair of Computer Science I
Module offered by: Institute of Computer Science

ECTS: 5
Method of grading: numerical grade
Only after succ. compl. of module(s): --

Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
This course covers the most important algorithms to draw graphs. Methods from the course Algorithmische Graphentheorie (Algorithmic Graph Theory) such as divide and conquer, flow networks, integer programming and the planar separator theorem will be used. We will become familiar with measures of quality of a graph drawing as well as algorithms to optimise these measures.

Intended learning outcomes:
The participants get an overview of graph visualisation and become familiar with typical tools. They consolidate their knowledge about the modelling and solving of problems with the help of graphs and graph algorithms.

Courses (type, number of weekly contact hours, language — if other than German):
V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus):
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
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<table>
<thead>
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<th>Module title</th>
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<tr>
<td>Image and Signal Processing in Physics</td>
<td>11-BSV-161-m01</td>
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<tr>
<td>Managing Director of the Institute of Applied Physics</td>
<td>Faculty of Physics and Astronomy</td>
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<tr>
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**Contents**

Periodic and aperiodic signals; principles of discreet and exact Fourier transformation; principles of digital signal and image processing; discretisation of signals/sampling theorem (Shannon); homogeneous and linear filters, convolution product; tapering functions and interpolation of images; the Parsival theorem, correlation and energetic observation; statistical signals, image noise, moments, stationary signals; tomography: Hankel and Radon transformation.

**Intended learning outcomes**

The students have advanced knowledge of digital image and signal processing. They know the physical principles of image processing and are familiar with different methods of signal processing. They are able to explain different methods and to implement them, especially in the field of tomography.

**Courses** (type, number of weekly contact hours, language — if other than German)

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<th>V (2) + Ü (2)</th>
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Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title
Quantum Information Technology

### Abbreviation
11-QUI-161-m01

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### Contents
Basic concepts of quantum mechanics, quantum bits and algorithms, quantal measurements, experimental approaches towards quantum computing (on the basis of photons, ions and nuclear spins), quantum operations and quantum noise, quantum information and communication.

### Intended learning outcomes
The students are familiar with the basic quantum mechanical terms of quantum information technology. They know experimental approaches for the realisation of quantum computers and for the transfer of quantum information.

### Courses
(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)
Module taught in: German or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

### Allocation of places
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### Additional information
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<td>Physics of Advanced Materials</td>
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**Contents**
General properties of various material groups such as liquids, liquid crystals and polymers; magnetic materials and superconductors; thin films, heterostructures and superlattices. Methods of characterising these material groups; two-dimensional layer materials.

**Intended learning outcomes**
The students know the properties and characterization methods of some modern materials.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (3) + R (1)
Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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### Module title
Spintronics

### Abbreviation
11-SPI-161-m01

### Module coordinator
Managing Director of the Institute of Applied Physics

### Module offered by
Faculty of Physics and Astronomy

### ECTS
6

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
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### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

### Contents
This lecture covers the basic principles of spin transport, with a particular emphasis on the phenomena of giant magnetoresistance and tunnel magnetoresistance. As a last point, we discuss new phenomena from the field of spin dynamics and current-induced spin phenomena.

### Intended learning outcomes
The students know the basic principles of spin transport models and the applications of spin transport in information technology. They have gained an overview of current findings in this field (giant magnetoresistance, tunnel magnetoresistance).

### Courses
(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
--
**Module title**
Solid State Physics 2

**Abbreviation**
11-FK2-161-m01

**Module coordinator**
Managing Director of the Institute of Applied Physics

**Module offered by**
Faculty of Physics and Astronomy

**ECTS**
8

**Method of grading**
Numerical grade

**Only after succ. compl. of module(s)**
--

**Duration**
1 semester

**Module level**
Graduate

**Other prerequisites**
--

**Contents**
Modern scattering methods; neutron scattering as a method to investigate the atomic and magnetic structure and excitations such as phonons and magnetic waves; resonant elastic X-ray scattering and absorption; investigation of magnetic, orbital and charge order; X-ray and neutron reflectometry; investigation of the structural, magnetic and electronic properties of thin films and superlattices; resonant inelastic X-ray scattering; investigation of excitations in solids and thin films; STEM ("scanning transmission electron microscopy"); further topics upon agreement.

**Intended learning outcomes**
The students know different modern scattering methods such as neutron scattering, resonant elastic X-ray scattering, modern scattering theory, X-ray and neutron reflectometry and resonant inelastic X-ray scattering. They are familiar with the theoretical principles and applications of these methods.

**Courses**
(type, number of weekly contact hours, language — if other than German)
V (4) + R (2)
Module taught in: German or English

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
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**Contents**


**Intended learning outcomes**

The students have specific and advanced knowledge in the field of solid-state spectroscopy. They know different types of spectroscopy and their fields of application. They understand the theoretical principles and the current developments in research.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester.

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title
Magnetism

### Abbreviation
11-MAG-161-m01

### Module coordinator
Managing Director of the Institute of Applied Physics

### Module offered by
Faculty of Physics and Astronomy

### ECTS
6

### Method of grading
Only after succ. compl. of module(s)

### Duration
1 semester

### Module level
graduate

### Other prerequisites
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### Contents
Dia- and paramagnetism, exchange interaction, ferromagnetism, antiferromagnetism, anisotropy, domain structure, nanomagnetism, superparamagnetism, experimental methods to measure magnetic properties, Kondo effect.

### Intended learning outcomes
The students know basic terms, concepts and phenomena of magnetism and measuring methods for magnetic experiments; they are skilled in simple model building and in the formulation of mathematical-physical approaches and are able to apply them to tasks in the stated areas; they have competencies in independently working on problems of these areas; they are able to evaluate the accuracy of observations and analyses.

### Courses
*(type, number of weekly contact hours, language — if other than German)*

- V (3) + R (1)

Module taught in: German or English

### Method of assessment
*(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)*

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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<td>Semiconductor Physics</td>
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<th><strong>Contents</strong></th>
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<tr>
<td>1. Symmetry properties</td>
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<tr>
<td>2. Crystal formation and electronic band structure</td>
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<tr>
<td>3. Optical excitations and their coupling effects</td>
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<tr>
<td>4. Electron-phonon coupling</td>
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<td>5. Temperature-dependent transport properties</td>
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<td>6. Magnetic semiconductors</td>
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<tr>
<th><strong>Intended learning outcomes</strong></th>
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<tbody>
<tr>
<td>The students are familiar with the principles of Semiconductor Physics. They understand the structure of semiconductors and know their physical properties and effects. They know important applications.</td>
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<th><strong>Courses</strong> (type, number of weekly contact hours, language — if other than German)</th>
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<td>V (3) + R (1) Module taught in: German or English</td>
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Module title: Optical Properties of Semiconductor Nanostructures

Abbreviation: 11-HNS-161-m01

Module coordinator: Managing Director of the Institute of Applied Physics

Module offered by: Faculty of Physics and Astronomy

ECTS: 6

Method of grading: numerical grade

Duration: 1 semester

Module level: graduate

Other prerequisites: --

Contents:
Semiconductor nanostructures are frequently referred to as "artificial materials". In contrast to atoms, molecules or macroscopic crystals, their electronic, optical and magnetic properties can be systematically tailored by changing their size. The lecture addresses technological challenges in the preparation of semiconductor nanostructures of varying dimensions (2D, 1D, 0D). It provides the basic theoretical concepts to describe their properties, with a focus on optical properties and light-matter coupling. Moreover, it discusses the challenges and concepts of novel optoelectronic and quantum photonic devices based on such nanostructures, including building blocks for quantum communication and quantum computing architectures.

Intended learning outcomes:
The students know the theoretical principles and characteristics of semiconductor nanostructures. They have knowledge of the technological methods to fabricate such structures, and of their applications to novel photonic devices. They are able to apply their knowledge to problems in this field of research.

Courses:
V (3) + R (1)
Module taught in: German or English

Method of assessment:
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

Allocation of places:
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Additional information:
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<td>Quantum Transport</td>
<td>11-QTH-161-m01</td>
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**Contents**

The lecture addresses the fundamental transport phenomena of electrons in nanostructures. This includes the topics of: ballistic and diffuse transport, electron interference effects, quantisation of conductivity, interaction phenomena between electrons, Coulomb blockade, thermoelectric properties, description of spin-dependent transport phenomena, topological insulators, solid-state quantum computers.

**Intended learning outcomes**

The students have mastered the basics of electronics of nanostructures in theory and practice. They know functions and applications of respective components.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
## Module title
**Methods of Observational Astronomy**

**Abbreviation**
11-ASM-161-m01

### Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

### Module offered by
Faculty of Physics and Astronomy

### ECTS
6

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

## Contents
Methods of observational astronomy across the electromagnetic spectrum. Evaluation of observational data from radio, optical, X-ray and gamma-ray telescopes.

## Intended learning outcomes
Overview of the methods used in observational astronomy in various parts of the electromagnetic spectrum (radio, optical, X-ray and gamma-ray energies). Knowledge of principles and applications of these methods and ability to conduct astronomical observations.

## Courses
(type, number of weekly contact hours, language — if other than German)

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<tr>
<th>Type</th>
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Module taught in: German or English

## Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

## Allocation of places
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## Additional information
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## Referred to in LPO I
(examination regulations for teaching-degree programmes)

--
### Module title

**Experimental Particle Physics**

### Abbreviation

11-TPE-161-m01

### Module coordinator

Managing Director of the Institute of Applied Physics

### Module offered by

Faculty of Physics and Astronomy

### ECTS

6

### Method of grading

numerical grade

### Only after succ. compl. of module(s)

--

### Duration

1 semester

### Module level

graduate

### Other prerequisites

--

### Contents

Physics with modern particle detectors at the LHC and at the Tevatron. Discovery of the Higgs boson. Search for supersymmetry and other physics beyond the standard model. Determination of the top quark mass and W mass as well as other parameters of the standard model. Introduction to modern methods of analysis and assessment of systematic errors.

### Intended learning outcomes

The students are familiar with the principles of modern particle detector physics, especially with currently open questions of Particle Physics, which are examined by using these detectors. They know modern methods of analysis and are able to put results into context and to assess their systematic uncertainties.

### Courses

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Module taught in: German or English

### Method of assessment

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

- Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)
### Module title
Introduction to Space Physics

### Abbreviation
11-ASP-161-m01

### Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

### Module offered by
Faculty of Physics and Astronomy

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### Contents
1. Overview
2. Dynamics of charged particles in magnetic and electric fields
3. Elements of space physics
4. The sun and heliosphere
5. Acceleration and transport of energetic particles in the heliosphere
6. Instruments to measure energetic particles in extraterrestrial space

### Intended learning outcomes
The students acquire basic knowledge of Space Physics, in particular regarding the characterisation of the dynamics of charged particles in space and the heliosphere. They know relevant parameters and theoretical concepts and corresponding measuring methods.

### Courses
(type, number of weekly contact hours, language — if other than German)

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Module taught in: German or English

### Method of assessment
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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

### Allocation of places
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**Contents**

1. Phenomenology of active galactic nuclei and extragalactic jets
2. Jet-emission processes
3. VLBI observations of jets
4. High-energy observations of jets
5. Multimessenger signatures of jets

**Intended learning outcomes**

The students acquire knowledge of multiwavelength astronomy by studying the observations of active galactic nuclei and their extragalactic jets. They gain insights into a special, not yet solved astrophysical question and practice writing an observational proposal.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)
Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title: Quantum Mechanics II

Abbreviation: 11-QM2-161-m01

Module coordinator: Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by: Faculty of Physics and Astronomy

ECTS: 8

Method of grading: numerical grade — only after successful completion of module(s)

Duration: 1 semester

Module level: undergraduate

Other prerequisites: --

Contents:
The contents of this lecture build upon and will be chosen in accordance with the topics of the Bachelor's degree course "Quantum Mechanics I". Topics might include:

for QM:
1. Historical introduction
2. Single-particle states in a central potential
3. Principles of quantum mechanics
4. Spin and angular momentum
5. Approximations of energy eigenvalues
6. Approximations for time-dependent problems
7. Second quantisation
8. Potential scattering
9. General scattering theory
10. Canonical formalism
11. Charged particles in electromagnetic fields
12. Quantum theory of radiation
13. Quantum entanglement

Intended learning outcomes:
The students acquire in-depth knowledge of advanced quantum mechanics. This knowledge is highly relevant to most of the theoretical Master's degree courses in Astrophysics, Particle Physics and Condensed Matter Physics. The completion of this course is highly recommended.

Courses (type, number of weekly contact hours, language — if other than German)

V (4) + R (2)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

Allocation of places:

Additional information:

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**Contents**

1. Mathematical Foundations  
2. Differential forms  
3. Brief Summary of the special relativity  
4. Elements of differential geometry  
5. Electrodynamics as an example of a relativistic gauge theory  
6. Field equations of the fundamental structure of general relativity  
7. Stellar equilibrium and other astrophysical applications  
8. Introduction to cosmology

**Intended learning outcomes**

The students become familiar with the principal physical and mathematical concepts of general relativity. The main topics include modern formulation on the basis of differential forms. Furthermore, the similarities between electrodynamics as a gauge theory and general relativity are emphasised. The students learn to apply the theory to simple models of stellar equilibrium and are introduced to basic elements of cosmology.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title

**Many Body Quantum Theory**

### Abbreviation

11.QVTP-161-m01

### Module coordinator

Managing Director of the Institute of Theoretical Physics and Astrophysics

### Module offered by

Faculty of Physics and Astronomy

### ECTS

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### Duration

1 semester

### Module level

graduate

### Other prerequisites

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### Contents

In this lecture, Quantum Physics of many-particle systems are introduced on the basis of the perturbative methods of the Green's functions. A possible outline might be:

1. Single-particle Green's function
2. Review of second quantisation
3. Perturbation theory using many-particle Green's functions at temperature T=0
4. Perturbation theory for finite temperatures
5. Landau theory of Fermi liquids
6. Superconductivity
7. One-dimensional systems and bosonisation

### Intended learning outcomes

The students acquire knowledge of the methods of quantum field theory in a non-relativistic context. This knowledge enables them to study properties of Fermi liquids (and bosonic systems) beyond the one-particle picture, and to understand the effects of interactions, including superconductivity and the Kondo effect.

### Courses (type, number of weekly contact hours, language — if other than German)

V (4) + R (2)

Module taught in: German or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Contents

1. Theory of critical phenomena in thermal equilibrium
2. Introduction into the physics out of equilibrium
3. Entropy production and fluctuation
4. Phase transitions away from equilibrium
5. Universality
6. Spin glasses
7. Theory of neural networks

### Intended learning outcomes

The students acquire in-depth knowledge of a wide variety of concepts and methods essential for a thorough understanding of cooperative phenomena in complex many-particle systems. The main focus includes a thorough understanding of the concepts of entropy, entropy production and universality. The students are prepared for research activities in different areas of physics of complex systems.

### Courses (type, number of weekly contact hours, language — if other than German)

- **V (2) + R (2)**
- Module taught in: German or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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- Assessment offered: In the semester in which the course is offered and in the subsequent semester.
- Language of assessment: German and/or English

### Allocation of places

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### Additional information

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<td>Quantum Information and Quantum Computing</td>
<td>11-QIC-161-m01</td>
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**Contents**

1. Brief summary of classical information theory
2. Quantum theory seen from the perspective of information theory
3. Composite systems and the Schmidt decomposition
4. Entanglement measures
5. Quantum operations, POVMs, and the theorems of Kraus and Stinespring
6. Quantum gates and quantum computers
7. Elements of the theory of decoherence

**Intended learning outcomes**

The students acquire a comprehensive understanding of quantum states and density matrices beyond the usual textbook interpretation. They learn how to safely handle tensor products and multipartite quantum systems. The main topics of the lecture include basic mathematical concepts of quantum information theory and the limits of quantum computing arising from decoherence.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
**Module title**
Theoretical Solid State Physics

**Abbreviation**
11-TFK-161-m01

**Module coordinator**
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**
Faculty of Physics and Astronomy

**ECTS**
8

**Method of grading**
numerical grade

**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
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### Contents
The contents of this two-term course will depend on the choice of the lecturer, and may include parts of the syllabus which could alternatively be offered as "Quantum Many Body Physics" (11-QVTP).

A possible syllabus may be:
1. Band structure (Sommerfeld theory of metals, Bloch theorem, k.p approach and effective Hamiltonians for topological insulators (TIs), bulk-surface correspondence, general properties of TIs)
2. Electron-electron interactions in solids (path integral method for weakly interacting fermions, mean field theory, random phase approximation (RPA), density functional theory)
3. Application of mean field theory and the RPA to magnetism
4. BCS theory of superconductivity

### Intended learning outcomes
During the two-semester lecture, the students acquire a basic understanding of many topics of Solid-State Physics, which are addressed in classical textbooks, and thereby advance their knowledge of the underlying concepts and the methods of description. The course builds upon the courses "Experimental Condensed Matter Physics" and "Quantum Mechanics".

### Courses (type, number of weekly contact hours, language — if other than German)
V (4) + R (2)
Module taught in: German or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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**Contents**

A continuation of the first semester (11-TFK) might be the following syllabus:

5. Advanced topics of the theory of superconductivity (Bogoliubov-de Gennes equations, effective field theory, Anderson-Higgs description of the Meissner effect)

6. Unconventional superconductors (e.g. copper-oxide high-Tc superconductors)

7. Green's function methods and Feynman diagrammatic technique

8. The Kondo Effect (Anderson's "poor mans scaling", renormalization group)

**Intended learning outcomes**

During the two-semester lecture, the students acquire a basic understanding of many topics of Solid-State Physics, which are addressed in classical textbooks, and thereby advance their knowledge of the underlying concepts and the methods of description. The course builds upon the courses "Experimental Condensed Matter Physics" and "Quantum Mechanics".

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + R (2)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes)
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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
**Module title**  
Field Theory in Solid State Physics

**Abbreviation**  
11-FTFK-161-m01

**Module coordinator**  
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**  
Faculty of Physics and Astronomy

**ECTS**  
8

**Method of grading**  
numerical grade

**Only after succ. compl. of module(s)**  
--

**Duration**  
1 semester

**Module level**  
graduate

**Other prerequisites**  
--

**Contents**

This will usually be a course on quantum many particle physics using the method of functional integration. An outline could be:

1. Coherent states and review of second quantization
2. The functional integral formalism at finite temperatures $T$
3. Perturbation theory at $T=0$
4. Order parameters and broken symmetry
5. Green's functions
6. The Landau theory of Fermi liquids
7. Further developments

**Intended learning outcomes**

The students are enabled to apply the modern methods of path and functional integrals to quantum many-particle systems. These methods complement the traditional methods of Green's functions and Feynman diagrams.

**Courses**  
(type, number of weekly contact hours, language — if other than German)

V (4) + R (2)  
Module taught in: German or English

**Method of assessment**  
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester.

Language of assessment: German and/or English

**Allocation of places**  
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**Additional information**  
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**Referred to in LPO I**  
(examination regulations for teaching-degree programmes)

--
Module title: Topological Order
Abbreviation: 11-TOPO-161-m01

Module coordinator: Managing Director of the Institute of Applied Physics
Module offered by: Faculty of Physics and Astronomy

ECTS: 6
Method of grading: numerical grade
Duration: 1 semester

Module level: graduate
Other prerequisites: --

Contents:
Topologically ordered phases possess no order in the conventional sense (i.e., no broken symmetry and no local order parameter). The order is instead characterized by topological quantum numbers. In the course, the general concepts will be illustrated with the study of specific examples of systems with topological order.

The topics discussed may include:
1. Fractional charge and statistics in quantized Hall fluids
2. Spin charge separation in spin chains and chiral spin liquids
3. Non-Abelian statistics of fractionalized excitations
4. Majorana zero modes in p-wave superconductors
5. Topological degeneracies on higher genus surfaces (e.g., torus geometry)
6. Spinons and visons in spin liquids including Kitaev models.

Intended learning outcomes:
The students acquire in-depth knowledge of topological order in quantum condensates.

Courses:
V (3) + R (1)

Module taught in: German or English

Method of assessment:
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
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<td>Topology in Solid State Physics</td>
<td>11-TFP-161-m01</td>
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<td>1 semester</td>
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**Contents**

1. Geometric phase in quantum systems
2. Mathematical basics of topology
3. Time-reversal symmetry
4. Hall conductance and Chern numbers
5. Bulk-boundary correspondence
6. Graphene (as a topological insulator)
7. Quantum Spin Hall insulators
8. Z2 invariants
9. Topological superconductors

**Intended learning outcomes**

The students acquire a theoretical understanding of topological concepts in modern Solid-State Physics. These concepts serve as a basis of many research activities of the Faculty of Physics and Astronomy at the University of Würzburg.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Theory of Superconductivity
---|---
Abbreviation | 11-TSL-161-m01

Module coordinator | Managing Director of the Institute of Theoretical Physics and Astrophysics
Module offered by | Faculty of Physics and Astronomy

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Contents


Intended learning outcomes

This lecture focuses on the understanding of unconventional superconductivity and the interactions with magnetism in the current research context. The first part of the lecture addresses conventional molecular field theory of superconductivity (BCS theory), which fails when applied to new material classes such as high-temperature superconductors. Subsequently, it introduces tools of quantum field theory necessary to expand BCS theory. Thereby it especially focuses on Meissner effect and Higgs mechanism. The last part of the lecture discusses current developments concerning the description and analysis of (un)conventional superconductors and their fascinating connection to competing magnetic phases.

Courses (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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Subdivided Module Catalogue for the Subject
MINT Teacher Education PLUS, Elite Network Bavaria (ENB)
, 120 ECTS credits

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<td>Computational Materials Science (DFT)</td>
<td>11-CMS-161-m01</td>
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| Module coordinator Module offered by |
|------------------------------------|---------------|
| Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy |

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</table>

**Contents**

1. Density functional theory (DFT)
2. Wannier functions and localized basis functions
3. Numerical evaluation of topological invariants
4. Hartree-Fock and static mean-field theory
5. Many-body methods for solid state physics
6. Anderson impurity model (AIM) and Kondo physics
7. Dynamical mean-field theory (DMFT)
8. DFT + DMFT methods for realistic modeling of solids
9. Strongly correlated electrons

**Intended learning outcomes**

Aside from the theoretical discussion of these topics, the students carry out hands-on exercises from the CIP pool. The participants are introduced to the use of DFT software packages such as VASP or Wien2k and to the construction of maximally localised Wannier functions through the projection of DFT results on atom orbitals with the software wannier90. Furthermore, the students learn how to construct many-particle solutions of AIM and observe border cases such as the Kondo regime. Impurity solvers such as exact diagonalisation or continuous-time quantum Monte Carlo are utilised to solve the self consistency equations of dynamic molecular field theory (DMFT). These steps are necessary to reach the peak of the lecture: a DFT-DMFT calculation of a strongly correlated transition metal oxide such as SrVO3.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (4) + R (2)

Module taught in: German or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

--
**Conformal Field Theory**

**Abbreviation**

11-KFT-161-m01

**Module coordinator**

Managing Director of the Institute of Theoretical Physics and Astrophysics

**ECTS**

6

**Method of grading**

Only after succ. compl. of module(s)

**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

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**Contents**

Conformal field theory (CFT) was developed in the 1980s and found immediate application in string theory and two-dimensional statistical mechanics, where critical exponents and correlation functions for many models (Ising, tricritical Ising, 3-state Potts, etc.) could be exactly calculated. The physical idea is that the principle of scale invariance is elevated from a global to a local invariance, which, for reasons of consistency, amounts to invariance under conformal transformations. This, in turn, yields a rich and fascinating mathematical structure for two-dimensional systems (either two space dimensions or one time and one space dimension). CFT has become relevant to many interesting areas of condensed matter physics, including Abelian and non-Abelian bosonisation, quantised Hall states (where the bulk wave function is described in terms of conformal correlators, and the edge in terms of 1+1 dimensional CFTs), the two-channel Kondo effect, fractional topological insulators, and in particular fault-tolerant topological quantum computers involving non-Abelian anyons (Ising and Fibonacci anyons, for example, owe their names to the fusion rules of the associated conformal fields.) A potential syllabus for the first term of the course is:

0. Introduction (scale and conformal invariance, critical exponents, the transverse Ising model at the self-dual point)

1. Conformal theories in D dimensions (conformal group, conformal algebra in 2D, constraints on correlation functions)

2. Conformal theories in D=2 (primary fields and correlation functions, quantum field theory, canonical quantisation and Noether’s theorem, radial quantisation and Polyakov’s theorem, time ordering and functional integration, the free boson and vertex operators, conformal Ward identities)

3. Central charge and Virasoro algebra (central charge, the Schwarzian derivative, free fermion, (Abelian) bosonisation, mode expansions and Virasoro algebra, cylinder geometry and Casimir effect, in- and out-states, highest weight states, descendant fields and operator product expansions, conformal blocks, duality and bootstrap)


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**Intended learning outcomes**

The students acquire practical and conceptional familiarity with the methods of conformal field theory. As the completion of “Quantum Mechanics II” (11-QM2) is the only prerequisite to take part in this course, the students also acquire basic knowledge of critical phenomena, quantum field theory and functional integrals. The course is primarily addressed to students of Theoretical Physics and aims to increase their general level of knowledge by becoming acquainted with a sophisticated subdiscipline with applications in many subdisciplines of Condensed Matter Physics.

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**Courses**

*(type, number of weekly contact hours, language — if other than German)*

V (3) + R (1)

Module taught in: German or English

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**Method of assessment**

*(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)*

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

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**Module title**  
Conformal Field Theory 2

**Abbreviation**  
11-KFT2-161-m01

**Module coordinator**  
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**  
Faculty of Physics and Astronomy

**ECTS**  
6

**Method of grading**  
Only after succ. compl. of module(s)

**Numerical grade**  
--

**Duration**  
1 semester

**Module level**  
graduate

**Other prerequisites**  
--

### Contents

5. Minimal models (critical statistical mechanics models (Ising, tricritical Ising, 3 state Potts model, restricted solid-on-solid models), correlation functions of the critical Ising model, fusion rules and Verlinde algebra, Landau-Ginzburg description of minimal models, modified Coulomb gas method and its application to the Ising model, superconformal models)

6. Free bosons and fermions (mode expansions, twist fields, fermionic zero modes and fermion parity)

7. Free fermions on the torus (operator implementation of the partition function, vacuum energies, representations of Virasoro algebra, modular group and fermionic spin structures, Virasoro characters, critical Ising model on the torus, Jacobi theta function identities)

8. Free bosons on the torus (Lagrangian formulation of the partition function, fermionisation, orbifolds in general, $S_1/Z_2$ orbifold, Gaussian and Ashkin-Teller models, duality between original and orbifold theories, marginal operators, the space of $c=1$ theories)

### Intended learning outcomes

The students acquire practical and conceptional familiarity with the methods of conformal field theory. As the completion of "Quantum Mechanics II" (11-QM2) is the only prerequisite to take part in this course, the students also acquire basic knowledge of critical phenomena, quantum field theory and functional integrals. The course is primarily addressed to students of Theoretical Physics and aims to increase their general level of knowledge by becoming acquainted with a sophisticated subdiscipline with applications in many subdisciplines of Condensed Matter Physics.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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<td>Magnetism and Spin Fluids</td>
<td>11-MSF-161-m01</td>
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**Module coordinator**
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**
Faculty of Physics and Astronomy

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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
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**Contents**
The contents of the course vary from year to year and include topics such as spin-wave theory, spin-chains, spin ladders and spin liquids with topological orders. Depending on the lecturer, the focus may lie on magnetically ordered systems or spin liquids. Possible topics are:

2. Magnetic order (Holstein-Primakoff bosons and spin-wave theory)
3. Valence bond solids in spin chains (Majumdar-Gosh and AKLT Models, spinon confinement and the Haldane gap)
4. Critical spin-1/2 chains (spinon excitations in the Haldane-Shastry model, holon excitations in the Kuramoto-Yokohama model)
5. Coupled spin chains and ladders
6. Chiral spin liquids (Abelian and possibly non-Abelian)
7. Kitaev’s toric code model (spinon and vison excitations)

**Intended learning outcomes**
The students develop an understanding of the electronic origins of magnetism, spin-wave theory, spin-charge separation in one dimensional systems and spin-liquids as examples of systems with a topological order in two dimensions.

**Courses (type, number of weekly contact hours, language — if other than German)**

V (3) + R (1)
Module taught in: German or English

**Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)**

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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

**Allocation of places**
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<td>Topological Quantum Physics</td>
<td>11-TQP-161-m01</td>
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**Contents**

The course is aimed at Masters students pursuing either experimental or theoretical work in their thesis. Depending on the lecturers emphasis, it is meant to provide an introduction to topological superconductors and insulators assuming only "Quantum mechanics II" (11-QM2) as a prerequisite. The contents may include:

1. Introduction to superconductivity (including BCS theory)
2. Majorana fermions and topological superconductors in 1D (Kitaev wires)
3. Topological superconductors in two dimensions (2D) (including Majorana edge states and non-Abelian statistics)
4. Integer quantum Hall effect and Chern insulators (Haldane model, Jackiw-Rebbi solitons and edge states)
5. Berry's phase and Chern invariants
6. Time reversal symmetry and topological insulators in 2D
7. Topological insulators in 3D

**Intended learning outcomes**

In-depth understanding of the topological concepts of Quantum Physics relevant to current research projects of Condensed Matter Physics at the University of Würzburg.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title
Renormalization Group and Critical Phenomena

Abbreviation
11-CRP-161-m01

Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by
Faculty of Physics and Astronomy

ECTS
6

Method of grading
numerical grade

Duration
1 semester

Module level
graduate

Other prerequisites
--

Contents
1. Phase transitions
2. Mean field theory
3. The concept of the renormalization group (RG) Phase diagrams and fixed points
4. Perturbation-theoretical renormalization group
5. Low-dimensional systems
6. Conformal symmetry

Intended learning outcomes
The students acquire profound knowledge of the principles of scale invariance and of the renormalisation group (RG) in Statistical Physics. They understand the concept of RG flow with respect to effective field theories in both statistical and quantum field theory.

Courses (type, number of weekly contact hours, language — if other than German)
V (3) + R (1)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

Allocation of places
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Additional information
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### Contents

1. Instability of Fermi systems in one dimension (1D)
2. Abelian bosonisation and Luttinger liquids (spinless fermions, correlation functions, models with spin, renormalization group, and the sine-Gordon model).

The below mentioned topics will be presented in different years:
3. Interacting fermions on a lattice (Hubbard model, t/J model, transport properties)
4. Bethe ansatz
5. Spin-1/2 chains
6. Disordered systems
7. Non-abelian bosonisation and the WZW model (Kac-Moody algebras, Sugawara construction, Knizhnik-Zamolodchikov equation, applications of the WZW model)

### Intended learning outcomes

The students become familiar with the peculiarities of one-dimensional (1D) electron systems and acquire the theoretical tools to understand phenomena relevant to experiments, including disorder effects and transport in 1D.

### Courses (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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<td>11-EIT-161-m01</td>
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**Contents**

The main topic of the course will usually be lattice gauge theories. The concepts may be taught and illustrated by elaborating on the role of lattice gauge theories in spin systems.

A possible outline might be:

1. Introduction to lattice gauge theories for spin systems
2. Phase transitions
3. The transfer matrix
4. The two-dimensional (2D) Ising model
5. Ising lattice gauge theory
6. Abelian lattice gauge theories
7. The planar Heisenberg (XY) model in 2D (Kosterlitz-Thouless transition)
8. Non-Abelian lattice gauge theories

**Intended learning outcomes**

The students acquire in-depth understanding of gauge fields in classical and Quantum Physics. They are able to apply this knowledge to spin systems, illustrating the interplay between microscopic models and field-theoretic descriptions.

**Courses** (type, number of weekly contact hours, language — if other than German)

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Module taught in: German or English

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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<td>11-GGD-161-m01</td>
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**Contents**

1. Elements of quantum field theory:
   - Quantisation of the free field
   - Interactions
   - Renormalisation Group
   - Gauge Fields
   - Conformal Symmetry
   - Large N expansion
   - Supersymmetry

2. Elements of gravity
   - Manifolds, coordinate covariance and metric
   - Riemann curvature
   - Maximally symmetric spacetimes
   - Black holes

3. Elements of string theory
   - Open and closed strings
   - Strings in background fields
   - Type IIB String Theory
   - D-Branes

4. The AdS/CFT correspondence
   - Statement of the correspondence
   - Near-horizon limit of D3-Branes
   - Field-operator correspondence
   - Tests of the correspondence: Correlation functions
   - Tests of the correspondence: Conformal anomaly
   - Holographic principle

5. Extensions to non-conformal theories
   - Holographic renormalisation group
   - Holographic C-Theorem

6. Applications I: Thermo- and hydrodynamics
   - Quantum field theory at finite temperature
   - Black holes
   - Holographic linear response formalism
   - Transport coefficients: Shear viscosity and conductivities

7. Applications II: Condensed matter physics
   - Finite charge density and Reissner-Nordström black holes
   - Quantum critical behaviour
   - Holographic fermions
   - Holographic superconductors
### Intended learning outcomes

The students acquire a thorough understanding of the foundations of gauge/gravity duality and the ability to carry out basic tests. Depending on the pre-existing knowledge and interests of the students, the module addresses a selection of the aforementioned topics. Knowledge of quantum mechanics and classical electrodynamics is a prerequisite for this course. Knowledge of quantum field theory and general relativity is useful, but not a prerequisite.

### Courses

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Assessment offered: In the semester in which the course is offered and in the subsequent semester.

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)
**Module title**: Introduction to Fractional Quantisation

**Abbreviation**: 11-EFQ-161-m01

**Module coordinator**: Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**: Faculty of Physics and Astronomy

**ECTS**: 6

**Method of grading**: Only after succ. compl. of module(s)

**Duration**: 1 semester

**Module level**: Graduate

**Other prerequisites**: --

**Contents**

The course will elaborate on instances of fractional quantisation in nature, mostly employing examples from the following list:

1. Midgap states in polyacethylene
2. Abelian quantised Hall states (Laughlin states, fractional charge and statistics, hierarchy states, effective Chern-Simons theory)
3. Non-Abelian quantised Hall states (Pfaffian states, Majorana fermions, non-Abelian statistics, Read-Rezayi states)
4. Spin chains (Haldane-Shastry model, spinon excitations, holon excitations in the Kuramoto-Yokoyama model, Yangian symmetry)

**Intended learning outcomes**

The students become familiar with emergent phenomena in many-particle systems and with Anderson’s philosophical principle of "More is different" by studying specific examples of quantum condensates exhibiting fractional quantisation.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester.

Language of assessment: German and/or English

**Allocation of places**: --

**Additional information**: --

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Module title**

Topological Effects in Electronic Systems

**Abbreviation**

11-TEF-161-m01

**Module coordinator**

Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**

Faculty of Physics and Astronomy

**ECTS**

6

**Method of grading**

numerical grade

Only after succ. compl. of module(s)

**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

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**Contents**

The continuous development of the field of topological phases including topological insulators, superconductors, and spin liquids requires a continuous adaptation of the graduate curriculum. The course aims to deepen the students' understanding of concepts related to contemporary research and/or to keep up with contemporary developments. The specific choice of topics will vary with the lecturers from year to year.

**Intended learning outcomes**

The course offers the opportunity to get acquainted with topics of immediate relevance to research conducted at the University of Würzburg.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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## Contents

The topics of the course will vary from year to year and may include the description of superconductors through classical field theory (the Higgs mechanism), non-linear sigma models for spin chains, Chern-Simons and axion theories as effective descriptions of quantised Hall fluids and topological insulators, respectively, or the SU(2) level k Wess-Zumino-Witten model as an example of a conformal field theory with a symmetry group (or algebra) beyond the Virasoro algebra.

## Intended learning outcomes

The students acquire an in-depth understanding of quantum field theory and its fundamental importance for almost all areas of Condensed Matter Physics.

## Courses (type, number of weekly contact hours, language — if other than German)

- **V (3) + R (1)**
  - Module taught in: German or English

## Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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## Allocation of places

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## Additional information

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**Module coordinator**
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**Module offered by**
Faculty of Physics and Astronomy

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**Contents**
Expanding space-time, Friedmannian cosmology, basics of general relativity, the early universe, inflation, dark matter, primordial nucleosynthesis, cosmic microwave background, structure formation, galaxies and galaxy clusters, intergalactic medium, cosmological parameters.

**Intended learning outcomes**
The students have basic knowledge of cosmology. They know the theoretical methods of cosmology and are able to relate them to observations. They have gained insights into current research topics and are able to process scientific questions.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (3) + R (1)
Module taught in: German or English

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<td>Theoretical Astrophysics</td>
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**Contents**

Topics in theoretical astrophysics such as e.g. white dwarfs, neutron stars and black holes, supernovae, pulsars, accretion and jets, shock waves, radiation transport, and gravitational lensing

**Intended learning outcomes**

Knowledge of basic processes and methods of Theoretical Astrophysics. Ability to formulate theoretical models.

**Courses** (type, number of weekly contact hours, language — if other than German)

| V (2) + R (2) | Module taught in: German or English |

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

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<td>High Energy Astrophysics</td>
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**Contents**

Radiative processes, interaction of light with matter, particle acceleration processes, pair creation, nuclear processes, pion production, astrophysical shock waves, kinetic equations

**Intended learning outcomes**

The student gains knowledge in fundamentals of High-Energy Astrophysics, such as particle acceleration and non-thermal radiative processes in astrophysical objects

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

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**Contents**

1. Symmetries  
2. Relativistic single-particle states  
3. Lagrange formalism for fields  
4. Field quantisation  
5. Scattering theory and S-matrix  
6. Gauge principle and interaction  
7. Perturbation theory  
8. Feynman rules  
9. Quantum electrodynamic processes in Born approximation  
10. Radiative corrections  
11. Renormalisation (optional)

**Intended learning outcomes**

The students have mastered the principles and underlying mathematics of relativistic quantum field theories. They know how to use perturbation theory and how to apply Feynman rules. They are able to calculate basics processes in the framework of quantum electrodynamics in leading order. Moreover, they have a basic understanding of radiative corrections and renormalisation.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + R (2)
Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
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<td>Quantum Field Theory II</td>
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<td>Managing Director of the Institute of Theoretical Physics and Astrophysics</td>
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<tr>
<td>1 semester</td>
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**Contents**

1. Generating Functionals
2. Path Integrals
3. Renormalization
4. Renormalization group
5. Gauge theories
6. Spontaneous Symmetry Breaking
7. Effective Field Theory (optional)

**Intended learning outcomes**

The students have advanced knowledge of the methods and concepts of quantum field theory. They have mastered the principles, especially of renormalisation and gauge theories. They are able to formulate and solve problems of quantum field theory by using the acquired calculation methods.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + R (2)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
## Module title
Theoretical Elementary Particle Physics

### Abbreviation
11-TEP-161-m01

### Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

### Module offered by
Faculty of Physics and Astronomy

### ECTS
8

### Method of grading
Only after succ. compl. of module(s)

### Duration
1 semester

### Module level
graduate

### Other prerequisites
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### Contents
1. Fundamental particles and forces
2. Symmetries and groups
3. Quark model of hadrons
4. Quark parton model and deep inelastic scattering
5. Principles of quantum field theory
6. Gauge theories
7. Spontaneous symmetry breaking
8. Electroweak standard model
9. Quantum chromodynamics
10. Extensions of the standard model.

### Intended learning outcomes
The students are familiar with the mathematical methods of Elementary Particle Physics. They understand the structure of the standard model based on symmetry principles and experimental observations. They know calculation methods for the processing of simple problems and processes of Elementary Particle Physics. Furthermore, they know the tests and limits of the standard model and the basics of extended theories.

### Courses (type, number of weekly contact hours, language — if other than German)
V (4) + R (2)
Module taught in: German or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
--
# Selected Topics of Theoretical Elementary Particle Physics

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<td>Selected Topics of Theoretical Elementary Particle Physics</td>
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</table>

## Contents

A selection of topics from the following fields will be covered in different years:

1. Advanced techniques for precision calculations of scattering amplitudes
2. Phenomenology of particle accelerators
3. Higgs physics
4. Top quark physics

## Intended learning outcomes

The students are familiar with the tests and limits of the standard model of Particle Physics, Higgs physics and neutrino physics. They are able to formulate extensions of the standard model. Furthermore, they know how to test these extensions in low energy experiments, at high energy colliders and in cosmology.

## Courses

(V (3) + R (1)

Module taught in: German or English

## Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

## Allocation of places

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## Additional information

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## Referred to in LPO I

(examination regulations for teaching-degree programmes)

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<td>Models Beyond the Standard Model of Elementary Particle Physics</td>
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**Module coordinator**
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**
Faculty of Physics and Astronomy

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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
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**Contents**

1. Principles of the standard model of Elementary Particle Physics  
2. Tests of the standard model in low energy experiments and at high energy colliders  
3. Neutrino physics  
4. Higgs physics.

In addition, a selection of topics from the following fields will be covered in different years:
- Phenomenology of experiments at the LHC,  
- particle cosmology,  
- extended gauge theories,  
- models with extended Higgs sectors,  
- supersymmetry,  
- models with additional space-time dimensions

**Intended learning outcomes**
The students are familiar with the tests and limits of the standard model of Particle Physics, Higgs physics and neutrino physics. They are able to formulate extensions of the standard model. Furthermore, they know how to test these extensions in low energy experiments, at high energy colliders and in cosmology.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (3) + R (1)
Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes)
or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).  
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Assessment offered: In the semester in which the course is offered and in the subsequent semester  
Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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<th>Module title</th>
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<tr>
<td>Professional Project Management</td>
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**Module coordinator**
holder of the Chair of Computer Science III

**Module offered by**
Institute of Computer Science

**ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** |
---|----------------------|------------------------------------------|
5          | numerical grade      | --                                       |

**Duration** | **Module level** | **Other prerequisites** |
---            |                 |                           |
1 semester    | graduate        | Simultaneous completion of module 10-I=PRJ is recommended. |

**Contents**
Project goals, project assignment, project success criteria, business plan, environment analysis and stakeholder management, initialisation, definition, planning, execution/control, finishing of projects, reporting, project communication and marketing, project organisation, team building and development, opportunity and risk management; conflict and crisis management, change and claim management; contract and procurement management, quality management, work techniques, methods and tools; leadership and social skills in project management, program management, multiproject management, project portfolio management, PMOs; peculiarities of software projects; agile project management/SCRUM, combination of classic and agile methods.

**Intended learning outcomes**
The students possess practically relevant knowledge about the topics of production management and/or professional project management. They are familiar with the critical success criteria and are able to initiate, define, plan, control and review projects.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

**Allocation of places**
--

**Additional information**
Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): SE, IT, IS, ES, LR, HCI.

**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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<table>
<thead>
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<th>Module title</th>
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<tr>
<td>Selected Topics in Software Engineering</td>
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**Contents**

Selected topics in software engineering.

**Intended learning outcomes**

The students possess an advanced knowledge about selected aspects of software engineering.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

**Allocation of places**

--

**Additional information**

Focuses available for students of the Master's programme Informatik (Computer Science, 120 ECTS credits): SE.

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Selected Topics in Internet Technologies

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<td>Selected Topics in Internet Technologies</td>
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</table>

Contents

Selected topics in computer communication, for example design aspects of future internet structures: setup and control structures of the internet, multicast protocols, protocols for multimedia communication, optical networks, control mechanisms for redundant and real-time communication networks, P2P networks, ad-hoc networks, or -- new concepts and technologies in mobile communication: digital modulation, signal propagation, channel coding, modern transmission technologies (adaptive modulation and coding, hybrid ARQ, OFDM, MIMO), MAC layer, mobileIP, routing in ad-hoc networks, vertical handover, UMTS IP multimedia subsystem, or -- planning and management methods in telecommunication networks: planning methods (forward engineering, reverse engineering), network management paradigms (central and decentral), framework for network management (IETF traffic engineering, ITU-T TMN, OSI management), planning and management methods (IP management mechanisms, network design, measurement, acquisition and evaluation of traffic and performance data, visualisation, result handling, simulation and analysis of networks), management tools, outlook and perspectives, or -- other current topics.

Intended learning outcomes

The students have a knowledge of advanced and current topics in the management and design of modern wired and wireless communication systems.

Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

Allocation of places

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Additional information

Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): IT.

Referred to in LPO I (examination regulations for teaching-degree programmes)

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<td>Selected Topics in Intelligent Systems</td>
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**Contents**

Selected topics in intelligent systems.

**Intended learning outcomes**

The students possess an advanced knowledge in the area of intelligent systems. They are able to understand solutions to complex problems in this area and to transfer them to related questions.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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**Additional information**

Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): IS.

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title
Selected Topics in Embedded Systems

Abbreviation
10-I=AKES-161-m01

Module coordinator
Dean of Studies Informatik (Computer Science)

Module offered by
Institute of Computer Science

ECTS
5

Method of grading
Numerical grade

Only after succ. compl. of module(s)
--

Duration
1 semester

Module level
Graduate

Other prerequisites
--

Contents
Selected topics in embedded systems.

Intended learning outcomes
The students possess specialised knowledge in the area of embedded systems. They are able to understand solutions to complex problems in this area and to transfer them to related questions.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
Written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

Allocation of places
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Additional information
Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): ES.

Referred to in LPO I (examination regulations for teaching-degree programmes)
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<td>Selected Topics in Aerospace Engineering</td>
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</table>

### Contents

Selected topics in aerospace engineering, for example: satellite communication, rocket science, propulsion systems, sensors and actuators for orientation control, perturbation of orbits, interplanetary orbits, rendezvous and docking, design of space ships, design of planetary bases, life support systems, special aspects of operations, payloads, optical systems, RADAR, earth monitoring, thermo management, structure of space ships, special areas of navigation, space environment, environment simulation, verification and test of space faring systems, space astronomy and planet missions, space medicine and biology, material science, quality management, space law, aeroflight topics, avionics for airplanes, air traffic control, areal navigation, pilot interfaces, air traffic control, air traffic management.

### Intended learning outcomes

The students possess an advanced knowledge about the respective topic of the selected area and are able to consider these foundations in their future plans of air or spaceborne systems.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Separate written examination for Master’s students.
Language of assessment: German and/or English creditable for bonus

### Allocation of places

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### Additional information

Focuses available for students of the Master’s programme Informatik (Computer Science, 120 ECTS credits): LR.

Referred to in LPO I (examination regulations for teaching-degree programmes)

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<td>Selected Topics in HCI</td>
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**Contents**

Selected topics in HCI.

**Intended learning outcomes**

The students understand the basic approach of human-computer interaction. They are able to understand the solutions to complex problems in this area and to transfer them to related questions.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Course type: alternatively S (2) or R (2) instead of Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

written examination (60 to 120 minutes).

If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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**Additional information**

Focuses available for students of the Master's programme Informatik (Computer Science, 120 ECTS credits): HCI.

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
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<th>Abbreviation</th>
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<tbody>
<tr>
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### Contents
Selected topics in computer science.

### Intended learning outcomes
The students are able to understand the solutions to complex problems in computer science and to transfer them to related questions.

### Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).
Language of assessment: German and/or English creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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**Contents**

German contents available but not translated yet.

Das Modul behandelt spezifische Themen der Hauptgruppen- und Übergangsmetallchemie. Schwerpunkte sind spezielle Verbindungen der Hauptgruppenelemente (HGE), Bindungssituation in HGE und HGE-Verbindungen, Stoffchemie der Übergangsmetalle und Koordinationschemie.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Die Studierenden sind in der Lage, spezielle Verbindungen der Hauptgruppenelemente zu charakterisieren und erklären. Er/Sie kann stoffchemische Eigenschaften von Übergangsmetallen beschreiben und Struktur sowie chemische und physikalische Aspekte von Koordinationsverbindungen analysieren.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (3) + S (3)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**

German contents available but not translated yet.

> Das Modul vertieft spezielle Synthese- und Analysemethoden der anorganischen Chemie. Im Schwerpunkt steht das Arbeiten unter Inertgas, Reinigungsmethoden, Spektrenanalyse sowie Kristallographie. Die Studierenden arbeiten selbständig im Labor, halten ihre Forschungsergebnisse in einem Praktikumsbericht fest und präsentieren diese in einem Vortrag.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

> Die Studierenden sind in der Lage, anspruchsvolle anorganische Synthese- und Analysemethoden experimentell durchzuführen sowie die erhaltenen Ergebnisse auszuwerten. Er/Sie kann Forschungsergebnisse in einem wissenschaftlichen Bericht formulieren und in einem Vortrag präsentieren.

**Courses** (type, number of weekly contact hours, language — if other than German)

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**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

> report on practical course (approx. 20 pages) and talk (approx. 15 minutes)

> Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title
Bioinorganic Chemistry

Abbreviation
08-ACM2-161-m01

Module coordinator
Lecturer of seminar "Anorganische Aspekte der Biochemie and Medizinischen Chemie" (Inorganic Aspects of Biochemistry and Medicinal Chemistry)

Module offered by
Institute of Inorganic Chemistry

ECTS
5

Method of grading
Numerical grade

Only after succ. compl. of module(s)
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Duration
1 semester

Module level
Graduate

Other prerequisites
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Contents
German contents available but not translated yet.

Das Modul führt in die Grundlagen der Bioanorganischen Chemie (BIC) ein. Es werden die Methoden der BIC, Struktur und Wirkungsweise Metall-haltiger Enzyme sowie Anwendungen der BIC als Diagnostika und Therapeutika behandelt.

Intended learning outcomes
German intended learning outcomes available but not translated yet.


Courses (type, number of weekly contact hours, language — if other than German)
S (3)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 45 to 90 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (15 to 30 minutes per candidate)

Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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**Module title** | **Abbreviation**
---|---
Solid state chemistry and inorganic materials | 08-ACM3-161-m01

**Module coordinator**

lecturer of seminar "Festkörperchemie and Anorganische Materialien" (Solid State Chemistry and Inorganic Materials)

**Module offered by**

Institute of Inorganic Chemistry

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**Contents**

German contents available but not translated yet.

Das Modul führt in die Festkörperchemie ein. Schwerpunkte sind Struktur, chemische und physikalische Eigenschaften, Synthesemethoden sowie ausgewählte Materialien von Festkörpern.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.


**Courses** (type, number of weekly contact hours, language — if other than German)

S (3)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**

German contents available but not translated yet.

Das Modul behandelt moderne stereoselektive Synthesemethoden. Schwerpunkt sind ausgewählte Totalsynthesen, Organometallchemie und Katalyse.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.


**Courses** (type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**

German contents available but not translated yet.

Das Modul bietet den Studierenden die Möglichkeit, in einem Arbeitskreis des Instituts für Organische Chemie mit zu arbeiten sowie spezifische Synthese- und Analysemethden kennen zu lernen.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Die Studierenden sind in der Lage, arbeitskreistypische synthetische, analytische und theoretische forschungsrelevante Inhalte zu beschreiben sowie anzuwenden.

**Courses** *(type, number of weekly contact hours, language — if other than German)*

P (20)
Module taught in: German or English

**Method of assessment** *(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)*

Log (approx. 15 to 20 pages) and talk (approx. 15 minutes)
Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** *(examination regulations for teaching-degree programmes)*

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**Contents**

German contents available but not translated yet.

Das Modul behandelt spezifische Themen der organischen Funktionsmaterialien. Schwerpunkte sind grundlegende physikalische Effekte, organische Festkörper, Anwendung organischer Funktionsmaterialien und organische und metallorganische Polymerchemie

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.


**Courses** (type, number of weekly contact hours, language — if other than German)

| S (3) |               |

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**

The module covers specific topics of molecular physiology and functional biochemistry in lectures and exercises.

**Intended learning outcomes**

After attending the module events, students have solid knowledge in molecular biology.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Practical course "Molecular Machines" for advanced students

**Abbreviation**

08-BC-VPMM-161-m01

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## Contents

German contents available but not translated yet.

Das Modul ermöglicht ein vertieftes Einarbeiten in ein Forschungsthema. Ausgewählte Methoden und Themen der Molekularbiologie und Biochemie; Klonierung, Mutagenese, Proteinexpression und -aufreinigung, RNA-Protein und Protein-Protein Interaktionsstudien, Isolierung und funktionelle Analyse von makromolekularen Komplexen.

## Intended learning outcomes

The student is able to deeply acquaint himself/herself with a specific research topic, and to present the results in a talk.

### Courses

| P (10) |

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Log (approx. 20 pages) and talk (approx. 15 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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**Contents**

German contents available but not translated yet.

Das Modul ermöglicht ein vertieftes Einarbeiten in ein Forschungsthema auf dem Gebiet der Proteindegradation in Eukaryoten.

**Intended learning outcomes**

The student is able to deeply acquaint himself/herself with a specific research topic, and to present the results in a talk.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (10)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Log (approx. 20 pages) and talk (approx. 15 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
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**Contents**

German contents available but not translated yet.


**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Der/Die Studierende beherrscht es, sich in ein Forschungsthema vertieft einzuarbeiten sowie die Ergebnisse im Rahmen eines Vortrags darzustellen. Der/Die Studierende ist in der Lage, mittels unterschiedlicher Methoden, verschiedene Mechanismen der allgemeinen und spezifischen Translationskontrolle entsprechend selbständig zu erarbeiten, die Ergebnisse fachgerecht aufzubereiten und verständlich zu präsentieren.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (10)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Log (approx. 20 pages) and talk (approx. 15 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Contents**

German contents available but not translated yet.

Das Modul beschäftigt sich mit der Frage nach Klonierung und Expression von Proteinkonstrukten für die Kristallisation. Es vermittelt die Grundlagen und Techniken der Kristallisation und Kristalloptimierung sowie der Kristallografischen Datensammlung.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Der/Die Studierende erwirbt ein Grundverständnis für die Herangehensweise bei der Wahl von Proteinkonstrukten für die Kristallisation. Er/Sie beherrscht nach Besuch der Modulveranstaltungen die grundlegenden Fertigkeiten und Techniken der Proteinkristallisation und Datensammlung/-verarbeitung.

**Courses** (type, number of weekly contact hours, language — if other than German)

- P (10)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

- Log (approx. 20 pages) and talk (approx. 15 minutes)
- Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title
Lab Course Material Science

### Abbreviation
08-FMM-MP-161-m01

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### Contents
German contents available but not translated yet.

Im Rahmen des Moduls werden zehn Experimente mit materialwissenschaftlichem Bezug aus einer größeren Auswahl durchgeführt.

### Intended learning outcomes
German intended learning outcomes available but not translated yet.

Der/Die Studierende verfügt über spezielle Kenntnisse in der Durchführung materialwissenschaftlicher Experimente.

### Courses (type, number of weekly contact hours, language — if other than German)
- P (8)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Vortestate/Nachtestate (pre and post-experiment examination talks approx. 15 minutes each, log approx. 5 to 10 pages each) and assessment of practical performance (2 to 4 random examinations)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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### Contents

German contents available but not translated yet.

Im Rahmen des Moduls erfolgt eine angeleitete vertiefte Einarbeitung in ein Forschungsthema sowie die Darstellung der erhaltenen Ergebnisse.

### Intended learning outcomes

German intended learning outcomes available but not translated yet.

Der/Die Studierende verfügt über spezielle Kenntnisse in der Durchführung materialwissenschaftlicher Experimente.

### Courses (type, number of weekly contact hours, language — if other than German)

P (10)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Log (approx. 15 pages) and talk (approx. 15 minutes)

Language of assessment: German and/or English

### Allocation of places

--

### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

--
### Module title
Polymers II

### Abbreviation
03-FU-PM2-161-m01

### Module coordinator
holder of the Chair of Functional Materials in Medicine and Dentistry

### Module offered by
Faculty of Medicine

### ECTS
5

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

## Contents
Deepend polymer synthesis methods, special polymers (block copolymers, co-polymerization techniques, complex polymer architectures), biodegradable polymers, polypeptides, natural polymers. We will discuss the application of the respective polymers: e.g. as biomaterials, for electrospinning, for the production of hydrogels and their behavior on surfaces.

## Intended learning outcomes
The student acquire advanced knowledge in polymer manufacturing, analysis and applications. This involves different synthetic routes with which the different molecules can be prepared from different starting materials. Students can estimate if and how fast a polymer degrades under given circumstances. Furthermore, they gain insight into the field of technically used polymers from nature. Each section also points to possible consequences / disadvantages that synthesis of the various polymers may have, thus drawing students' understanding to ethical concerns.

## Courses
(type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)

## Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) talk (approx. 30 minutes)

Language of assessment: German and/or English

## Allocation of places
--

## Additional information
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## Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Module title
Advanced organometallic chemistry and its application in homogeneous catalysis

### Abbreviation
08-HKM2-161-m01

### Module coordinator
Lecturer of the seminar "Spezielle Metallorganische Chemie und deren Anwendung in der Homogenkatalyse"

### Module offered by
Institute of Inorganic Chemistry

### ECTS
5

### Method of grading
Numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
Graduate

### Other prerequisites
--

### Contents
Das Modul bietet die Möglichkeit, Elementorganische Verbindungen der Übergangsmetalle mit homogenkatalytischen Anwendungen im Detail zu betrachten.

### Intended learning outcomes

### Courses (type, number of weekly contact hours, language — if other than German)
S (3)

Module taught in: German or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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**Module coordinator**

lecturer of the seminar "Spezielle Metallorganische Chemie und deren Anwendung in der Homogenkatalyse"

**Module offered by**

Institute of Inorganic Chemistry

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**Contents**

German contents available but not translated yet.


**Intended learning outcomes**

German intended learning outcomes available but not translated yet.


**Courses**

(type, number of weekly contact hours, language — if other than German)

P (6)
Module taught in: German or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

report on practical course (approx. 10 pages) and talk (approx. 15 minutes)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

--
## Module title

Practical course "Homogeneous catalysis in Organic Chemistry"

### Abbreviation

08-HKM3OC-161-m01

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<td>Institute of Organic Chemistry</td>
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### ECTS | Method of grading | Only after succ. compl. of module(s) |
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## Contents

German contents available but not translated yet.


## Intended learning outcomes

German intended learning outcomes available but not translated yet.


### Courses (type, number of weekly contact hours, language — if other than German)

P (6)
Module taught in: German or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

report on practical course (approx. 10 pages) and talk (approx. 15 minutes)
Language of assessment: German and/or English

## Allocation of places

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## Additional information

--

## Referred to in LPO I (examination regulations for teaching-degree programmes)

--
### Module title

**Advanced transition metal chemistry**

### Abbreviation

08-HKM4-161-m01

### Module coordinator

Lecturer of the seminar "Spezielle Übergangsmetallchemie"

### Module offered by

Institute of Inorganic Chemistry

### ECTS

5

### Method of grading

Numerical grade

### Only after succ. compl. of module(s)

--

### Duration

1 semester

### Module level

Graduate

### Other prerequisites

--

### Contents

German contents available but not translated yet.

Das Modul vertieft Inhalte der Stoffchemie von Übergangsmetallen und der Koordinationschemie. Es führt in die Bioanorganische Chemie ein und zeigt aktuelle Entwicklungen in der Übergangsmetallchemie auf.

### Intended learning outcomes

German intended learning outcomes available but not translated yet.

Die Studierenden sind in der Lage, Übergangsmetalle und Koordinationsverbindungen auf fachlich hohem Niveau zu erklären. Er/Sie kann grundlegende Inhalte der Bioanorganischen Chemie darstellen.

### Courses (type, number of weekly contact hours, language — if other than German)

S (3)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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### Contents

German contents available but not translated yet.

Ausgewählte Methoden und Themen der Medizinischen Chemie (Synthese, Testung, Analytik, Theorie, Pharmakokinetik).

### Intended learning outcomes

German intended learning outcomes available but not translated yet.

Der/Die Studierende verfügt über Kenntnisse der Medizinischen Chemie und kann die Inhalte in praktischen Versuchen anwenden.

### Courses

(type, number of weekly contact hours, language — if other than German)

P (10)

Module taught in: German or English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Vortestate/Nachtestate (pre and post-experiment examination talks approx. 15 minutes each, log approx. 5 to 10 pages each) and assessment of practical assignments (2 to 4 random examinations) as well as report (30 to 50 pages)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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**Contents**

German contents available but not translated yet.

Chemie der Arzneistoffe, gegliedert nach Indikationsgebieten; Prinzipien der Arzneistoffentwicklung, Strategien der Wirkstofffindung; Struktur-Wirkungs-Beziehungen; Molekulare Wirkmechanismen; pharmakologische Grundlagen der behandelten Arzneistoffe; Analytik der Arzneistoffe; Synthese der Arzneistoffe; Biotransformation, Pharmakokinetik einzelner Arzneistoffe; Geschichte der Arzneistoffentwicklung an Beispielen.

**Intended learning outcomes**

The students acquire knowledge of pharmaceutic/medical chemistry and the according methods of their characterization.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module title | Abbreviation
---|---
Pharmaceutical/Medicinal Chemistry 2 | 08-MCM2b-161-m01

Module coordinator | Module offered by
lecturers Pharmazeutische Chemie (Pharmaceutical Chemistry) | Institute of Pharmacy and Food Chemistry

ECTS | Method of grading | Only after succ. compl. of module(s)
5 | numerical grade | --

Duration | Module level | Other prerequisites
1 semester | graduate | --

Contents

German contents available but not translated yet.

Chemie der Arzneistoffe, gegliedert nach Indikationsgebieten; Prinzipien der Arzneistoffentwicklung, Strategien der Wirkstofffindung; Struktur-Wirkungs-Beziehungen; Molekulare Wirkmechanismen; pharmakologische Grundlagen der behandelten Arzneistoffe; Analytik der Arzneistoffe; Synthese der Arzneistoffe; Biotransformation, Pharmakokinetik einzelner Arzneistoffe; Geschichte der Arzneistoffentwicklung an Beispielen.

Intended learning outcomes

The students acquire knowledge of pharmaceutic/medical chemistry and the according methods of their characteristics.

Courses (type, number of weekly contact hours, language — if other than German)

V (3)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

Allocation of places

--

Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

--
### Module title
Supramolecular Chemistry (Practical Course)

### Abbreviation
08-SCM2-161-m01

### Module coordinator
lecturer of lecture "Supramolekularen Chemie (Organische Chemie/Physikalische Chemie)"

### Module offered by
Faculty of Chemistry and Pharmacy

### ECTS
5

### Method of grading
Only after succ. compl. of module(s)

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### Duration
1 semester

### Module level
graduate

### Other prerequisites
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### Contents
German contents available but not translated yet.

Das Modul bietet den Studierenden die Möglichkeit, grundlegende Versuche zum Thema Supramolekularer Chemie praktisch durchzuführen. Es werden Wirt-Gast-Komplexe, Farbstoffaggregate und Nanopartikel synthetisiert sowie mit spezifischen Analysemethoden charakterisiert.

### Intended learning outcomes
German intended learning outcomes available but not translated yet.


### Courses
(type, number of weekly contact hours, language — if other than German)

P (6)

Module taught in: German or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Vorteststate/Nachtestate (pre and post-experiment examination talks approx. 15 minutes each, log approx. 5 to 10 pages each) and assessment of practical performance (2 to 4 random examinations)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

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<td>graduate</td>
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### Contents

The module deepens special synthetic and analytical methods of Supramolecular Chemistry. The students work independently in the laboratory, record their research results and present them in a talk.

### Intended learning outcomes

The students are able to carry out demanding synthetic and analytical methods in the field of Supramolecular Chemistry experimentally and to evaluate the results. He/She can present their research results in a talk.

### Courses

(type, number of weekly contact hours, language — if other than German)

P (6)
Module taught in: German or English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

presentation (approx. 20 minutes)
Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
**Module title**
Renormalization Group Methods in Field Theory

**Abbreviation**
11-RMFT-161-m01

**Module coordinator**
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**
Faculty of Physics and Astronomy

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<th>Method of grading</th>
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<td>1 semester</td>
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</table>

**Contents**
This course is complementary to the discussion of Wilson’s renormalisation group (RG) as covered in the course "Renormalisation Group and Critical Phenomena" (11-CRP). It focuses on the diagrammatic formulation of RG flow equations and its relation to diagrammatic perturbation expansions. This is of particular relevance for interacting fermion systems in the context of functional renormalisation groups. An outline of the course might be:
1. Wilson’s RG
2. Path integrals of interacting fermions
3. Bethe-Salpeter equation
4. RG flow equations for the one-particle and two-particle vertex
5. Comparison of flow equations with diagrammatic resummation schemes (such as the random phase approximation)
6. RG flow equations for spin systems.

**Intended learning outcomes**
The students become familiar with the modern diagram-based description of many-particle systems. This knowledge serves as a theoretical basis for the examination of phenomena such as superconductivity, charge and spin density waves, and nematic instabilities.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (4) + R (2)
Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).
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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
--
Module title | Abbreviation
--- | ---
Introduction to Plasma Physics | 11-EPP-161-m01

Module coordinator | Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
--- | --- | ---
6 | numerical grade | --

Duration | Module level | Other prerequisites
--- | --- | ---
1 semester | graduate | --

Contents

Plasma Astrophysics: Dynamics of charged particles in electric and magnetic fields, magnetohydrodynamics, transport equations for energetic particles, properties of magnetic turbulence, propagation of solar particles within the solar wind, particle acceleration via shock waves and via interaction with plasma turbulence, particle acceleration and transport in galaxies and other astrophysical objects, cosmic radiation.

Intended learning outcomes

The students have knowledge of the basic processes of Plasma Astrophysics.

Courses (type, number of weekly contact hours, language — if other than German)

V (2) + R (2)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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Module title: Computational Astrophysics

Abbreviation: 11-NMA-161-m01

Module coordinator: Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by: Faculty of Physics and Astronomy

ECTS: 6
Method of grading: numerical grade
Only after succ. compl. of module(s):

Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:

Intended learning outcomes:
The students are able to solve typical problems and equations of Astrophysics and other subdisciplines of Physics with the help of numerical simulations. They are especially capable of choosing adequate strategies to approach such problems and of validating the results.

Courses:
V (3) + R (1)
Module taught in: German or English

Method of assessment:
(a) written examination (approx. 90 to 120 minutes) or
(b) oral examination of one candidate each (approx. 30 minutes) or
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Assessment offered: In the semester in which the course is offered and in the subsequent semester.
Language of assessment: German and/or English

Allocation of places:
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Additional information:
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<tr>
<td>Organic Semiconductors</td>
<td>11-OHL-161-m01</td>
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**Contents**

Fundamentals of organic semiconductors, molecular and polymer electronics and sensor technology, applications.

**Intended learning outcomes**

The students have advanced knowledge of organic semiconductors.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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<td>Biophysical Measurement Technology in Medical Science</td>
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### Contents

The lecture covers the physical principles of imaging techniques and their application in Biomedicine. The main topics are conventional X-ray technique, computer tomography, imaging techniques of nuclear medicine, ultrasound and MR-tomography. The lecture additionally addresses the systems theory of imaging systems and digital image processing.

### Intended learning outcomes

The students know the physical principles of imaging techniques and their application in Biomedicine. They understand the principles of image generation and are able to explain different techniques and interpret simple images.

### Courses (type, number of weekly contact hours, language — if other than German)

- V (3) + R (1)

Module taught in: German or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Nano-Optics

Managing Director of the Institute of Applied Physics

Faculty of Physics and Astronomy

Only after succ. compl. of module(s)

The lecture conveys theoretical fundamentals, experimental techniques, and applications of nano-optics starting from the discussion of the focusing of light. Based on this, the fundamentals of modern far-field optical microscopy are discussed. In the following, the near-field optical microscopy is introduced and discussed. As a further basis, quantum emitters are introduced and their light emission in nano-environments is derived. Plasmons in 2D, 1D and 0 dimensions are introduced and discussed in detail. This finally leads to the concept of optical antennas.

The students have specific and advanced knowledge in the field of nano-optics. They are familiar with the theoretical principles and application areas of nano-optics and with current developments in this field.

V (3) + R (1)

Module taught in: German or English

Module offered by

Faculty of Physics and Astronomy

Method of grading

Only after succ. compl. of module(s)

Method of assessment

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

Allocation of places

Additional information

Referred to in LPO I (examination regulations for teaching-degree programmes)
Module title: Low Dimensional Structures
Abbreviation: 11-NDS-161-m01

Module coordinator: Managing Director of the Institute of Applied Physics
Module offered by: Faculty of Physics and Astronomy

ECTS: 6
Method of grading: numerical grade
Duration: 1 semester
Module level: graduate
Other prerequisites: Approval from examination committee required.

Contents:
Low-dimensional structures: Crystal lattice symmetry. Lattice dynamics and growth techniques of low-dimensional structures. Comparison between these structures and volume solids. X-ray diffractometry. Molecular beam epitaxy.

Intended learning outcomes:
The students have knowledge of the theoretical principles of the growth of low dimensional structures. They know methods of producing and analysing such structures. They know the bandstructures of the most important semiconductors as well as the fabrication and characteristics of semiconductor heterostructures and MOS-diodes. They are familiar with the subband structure of semiconductor heterostructures and MOS-diodes and can evaluate the importance of many-particle effects. They are able to solve problems related to potentials in one dimension by applying Poisson's equation. They know the $k\cdot p$ perturbation theory and can deduce the 2D subband structure from the bulk band structure. They have basic knowledge of the meaning of gauging, Landau-quantisation, filling factor and Landau degeneracy. They understand the dependence of various physical properties on the filling factor, and are able to solve implicit problems via numerical methods. They are familiar with elementary excitations in two-dimensional systems.

Courses (type, number of weekly contact hours, language — if other than German):
V (3) + R (1)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus):
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Language of assessment: German and/or English

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
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Module title | Abbreviation
---|---
Superconductivity | 11-SUP-161-m01

| Module coordinator | Module offered by |
---|---|
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy |

| ECTS | Method of grading | Only after succ. compl. of module(s) |
---|---|---|
6 | numerical grade | -- |

| Duration | Module level | Other prerequisites |
---|---|---|
1 semester | graduate | -- |

Contents
Physical principles of superconductors and their applications (among others development of technological platforms, methods of material sciences for calculating temperature profiles in superconductors)

**Intended learning outcomes**
The students have a basic understanding of superconductivity as a macroscopic quantum phenomenon. They are able to evaluate the contributions of materials sciences to the development of superconductivity.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (3) + R (1)
Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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Subdivided Module Catalogue for the Subject
MINT Teacher Education PLUS, Elite Network Bavaria (ENB)

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<tr>
<td>Advanced Topics in Solid State Physics</td>
<td>11-CSFM-161-m01</td>
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</table>

Contents

This module will enable the lecturers of Condensed Matter Physics to teach advanced courses on topics not covered in any of the other modules. These topics may relate either to recent research developments or to subjects not included in the regular curriculum.

Intended learning outcomes

The students advance their knowledge and understanding of an advanced topic of Condensed Matter Physics and acquire insights into the connections between research and teaching.

Courses (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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<tr>
<td>Advanced Topics in Astrophysics</td>
<td>11-CSAM-161-m01</td>
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**Module coordinator**
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**
Faculty of Physics and Astronomy

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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
Approval from examination committee required.

**Contents**
In-depth study of particular current topics of Astrophysics. The concepts of Astrophysics which will be discussed include: Stellar structure, formation and development, radiation transport, gas dynamics, heating and cooling processes of the interstellar medium, astrochemistry, accretion and jets, galaxy formation or similar topics.

**Intended learning outcomes**
The students have advanced knowledge of the subdisciplines of Astrophysics and are able to work on current scientific questions.

**Courses**
(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)

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Module title | Abbreviation
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Visiting Research | 11-FPA-161-m01

Module coordinator | Module offered by
chairperson of examination committee | Faculty of Physics and Astronomy

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Duration | Module level | Other prerequisites
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graduate | Approval from examination committee required.

Contents
Independent work on a current research topic of Experimental and Theoretical Physics. Implementation of scientific experiments including analysis and documentation of the results, especially in the context of research visits to other universities or research institutes.

Intended learning outcomes
The students are able to independently work on a current research area of Experimental or Theoretical Physics, to conduct and analyse scientific experiments and to document the results.

Courses (type, number of weekly contact hours, language — if other than German)
R (0)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
project report (10 to 20 pages)
Language of assessment: German and/or English

Allocation of places
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Additional information
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<td>Current Topics in Experimental Physics</td>
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**Contents**

Current topics in experimental physics. Credited academic achievements, e.g. in case of change of university or study abroad.

**Intended learning outcomes**

The students have advanced competencies corresponding to the requirements of a module of Experimental Physics of the Master's programme. They have knowledge of a current subdiscipline of Experimental Physics and understand the measuring and/or evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + R (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Refereed to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Current Topics in Experimental Physics</td>
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**Contents**

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**Intended learning outcomes**

The students have advanced competencies corresponding to the requirements of a module of Experimental Physics of the Master's programme. They have knowledge of a current subdiscipline of Experimental Physics and understand the measuring and/or evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Contents

Current topics in Experimental Physics. Credited academic achievements, e.g. in case of change of university or study abroad.

### Intended learning outcomes

The students have advanced competencies corresponding to the requirements of a module of Experimental Physics of the Master's programme. They have knowledge of a current subdiscipline of Experimental Physics and understand the measuring and/or evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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Module title: Current Topics in Experimental Physics
Abbreviation: 11-EXE8-161-m01

Module coordinator: chairperson of examination committee
Module offered by: Faculty of Physics and Astronomy

ECTS: 8
Method of grading: numerical grade
Duration: 1 semester
Module level: graduate
Other prerequisites: Approval from examination committee required.

Contents:
Current topics in experimental physics. Credited academic achievements, e.g. in case of change of university or study abroad.

Intended learning outcomes:
The students have advanced competencies corresponding to the requirements of a module of Experimental Physics of the Master’s programme. They have knowledge of a current subdiscipline of Experimental Physics and understand the measuring and/or evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

Courses:
V (4) + R (2)

Method of assessment:
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Language of assessment: German and/or English

Allocation of places:

Additional information:

Referred to in LPO I (examination regulations for teaching-degree programmes):
### Module title

Current Topics in Experimental Physics

### Abbreviation

11-EXE6A-161-m01

### Module coordinator

chairperson of examination committee

### Module offered by

Faculty of Physics and Astronomy

### ECTS

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### Duration

1 semester

### Module level

graduate

### Other prerequisites

Approval from examination committee required.

### Contents

Current topics in experimental physics. Credited academic achievements, e.g. in case of change of university or study abroad.

### Intended learning outcomes

The students have advanced competencies corresponding to the requirements of a module of Experimental Physics of the Master’s programme. They have knowledge of a current subdiscipline of Experimental Physics and understand the measuring and/or evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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Module title: Current Topics in Physik
Abbreviation: 11-EXP6-161-m01

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Contents

Current topics in experimental or theoretical physics. Credited academic achievements, e.g. in case of change of university or study abroad.

Intended learning outcomes

The students have advanced competencies corresponding to the requirements of a module of Experimental or Theoretical Physics of the Master’s programme of Nanostructure Technology. They have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

Courses (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

---
Subdivided Module Catalogue for the Subject
MINT Teacher Education PLUS, Elite Network Bavaria (ENB)

Module title
Thermodynamics and Economics

Abbreviation
11-TDO-161-m01

Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by
Faculty of Physics and Astronomy

ECTS
6

Method of grading
Only after succ. compl. of module(s)

Time required (not) successfully completed
--

Duration
1 semester

Module level
graduate

Other prerequisites
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Contents
Energy and economic growth, entropy production, emission reduction. Part I describes the role of energy conversion in the development of the universe, the evolution of life and the unfolding of civilisation. The density of entropy production of non-equilibrium thermodynamics shows the significance of the second law of thermodynamics for ecological damage and resource consumption. Energy conversion, entropy production and natural resources define the technological and ecological boundaries of industrial economic growth.

Part 2 analyses how the factors capital, work, energy and creativity produce the goods and services of a national economy and determine economic growth. The productive power of cheap energy by far exceeds that of expensive labour. Within the current system of taxes and social security contributions, this discrepancy between power and costs of production factors leads to job cuts, waste of resources, impoverishment of nations and growing social tensions. The course discusses how factor income taxation can counteract this development.

Part 3 includes seminar presentations, comprises the techniques of rational energy use and non-fossil energy use, and introduces the optimisation programme deeco (Dynamic Energy, Emission and Cost Optimization).

Intended learning outcomes
The students understand that energy conversion and entropy production are going to play an important role in the world’s economic and social development. As an extension of economic theory, the students know the connections between thermodynamics and economy as well as the productive physical basis of modern economies. They are able to apply the acquired knowledge to particular problems.

NOTE: this is the module that was run by Prof. Dr. R. Kümmel, who has now retired. As the module was tailored to his own theory of economy, it has yet to be decided whether we will continue to offer this module.

Courses (type, number of weekly contact hours, language — if other than German)
V (3) + R (1)

Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

Allocation of places
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Additional information
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**Contents**

Current topics in Theoretical Physics. Credited academic achievements, e.g. in case of change of university or study abroad.

**Intended learning outcomes**

The students have advanced competencies corresponding to the requirements of a module of Theoretical Physics of the Master’s programme. They have advanced specialist knowledge of a subdiscipline of Theoretical Physics and have mastered the required methods. They are able to apply the acquired methods to current problems of Theoretical Physics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + R (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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Current topics in theoretical physics. Credited academic achievements, e.g. in case of change of university or study abroad.

## Intended learning outcomes

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## Courses (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

## Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

## Allocation of places

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## Additional information

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**Intended learning outcomes**

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**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module title | Abbreviation
---|---
Current Topics of Theoretical Physics | 11-EXT8-161-m01

Module coordinator | Module offered by
chairperson of examination committee | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
8 | numerical grade | --

Duration | Module level | Other prerequisites
1 semester | graduate | Approval from examination committee required.

Contents

Current topics in Theoretical Physics. Credited academic achievements, e.g. in case of change of university or study abroad.

Intended learning outcomes

The students have advanced competencies corresponding to the requirements of a module of Theoretical Physics of the Master's programme. They have advanced specialist knowledge of a subdiscipline of Theoretical Physics and have mastered the required methods. They are able to apply the acquired methods to current problems of Theoretical Physics.

Courses (type, number of weekly contact hours, language — if other than German)

V (4) + R (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

Allocation of places

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Additional information

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**Contents**

Current topics in Theoretical Physics. Credited academic achievements, e.g. in case of change of university or study abroad.

**Intended learning outcomes**

The students have advanced competencies corresponding to the requirements of a module of Theoretical Physics of the Master’s programme. They have advanced specialist knowledge of a subdiscipline of Theoretical Physics and have mastered the required methods. They are able to apply the acquired methods to current problems of Theoretical Physics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

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Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title
Current Topics in Physik 11-EXP6A-161-m01

Module coordinator
Chairperson of examination committee

Module offered by
Faculty of Physics and Astronomy

ECTS 6 Numerical grade --

Method of grading Only after succ. compl. of module(s)

Duration 1 semester Graduate Approval from examination committee required.

Module level

Other prerequisites

Contents
Current topics in Experimental or Theoretical Physics. Credited academic achievements, e.g. in case of change of university or study abroad.

Intended learning outcomes
The students have advanced competencies corresponding to the requirements of a module of Experimental or Theoretical Physics of the Master's programme of Nanostructure Technology. They have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

Courses (type, number of weekly contact hours, language — if other than German)
V (3) + R (1)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).
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Language of assessment: German and/or English

Allocation of places
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Additional information
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**Module coordinator**
holder of the Chair of Computer Science VII

**Module offered by**
Institute of Computer Science

**ECTS**
8

**Method of grading**
umerical grade

**Only after succ. compl. of module(s)**
--

**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
--

**Contents**

**Intended learning outcomes**
The students master system aspects of the layouting of technical systems. Using the example of spacecraft, major subsystems and their integration into a working whole are being analysed.

**Courses**
(type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)
Module taught in: English

**Method of assessment**
type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus
written examination (approx. 60 to 120 minutes)
Language of assessment: English
creditable for bonus

**Allocation of places**
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**Additional information**
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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)
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Module title | Abbreviation
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Overview Higher Analysis for Teaching Degree (German Gymnasium) (Differential Equations and Complex Analysis, or Advanced Analysis and Complex Analysis) | 10-M-HHA-Ü-162-m01

| Module coordinator | Module offered by |
--- | ---
Dean of Studies Mathematik (Mathematics) | Institute of Mathematics |

| ECTS | Method of grading | Only after succ. compl. of module(s) |
--- | --- | ---
10 | numerical grade | -- |

| Duration | Module level | Other prerequisites |
--- | --- | ---
1 semester | undergraduate | -- |

### Contents

**Complex Analysis** (complex differentiability and the Cauchy-Riemann differential equation, path integrals and Cauchy integral theorems, isolated singularities, meromorphic functions and Laurent series, residue theorem and applications, Weierstrass factorization theorem and Mittag-Leffler theorem, conformal maps) and either

**Advanced Analysis** (advanced analysis in several variables, Lebesgue integration) or

**Ordinary Differential Equations** (existence and uniqueness theorem, continuous dependance of solutions on initial data, systems of linear differential equations, matrix exponential series, higher order linear differential equations).

### Intended learning outcomes

The student is acquainted with fundamental concepts and methods in complex analysis and a further topic in higher analysis (theory of ordinary differential equations or Lebesgue integration). He/She is able to relate these concepts with one another, and realises the advantages of thinking across the borders of different branches in mathematics.

### Courses (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

oral examination of one candidate each (20 to 40 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th>Module title</th>
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<tbody>
<tr>
<td>Overview Algebra and Geometry (Differential Geometry or Projective Geometry) for Teaching Degree (German Gymnasium)</td>
<td>10-M-HAG-Ü-162-m01</td>
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<td>1 semester</td>
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**Contents**

**Algebra** (fundamental algebraic structures: groups, rings, fields; Galois theory) and either

**Differential Geometry** (curves in Euclidean spaces, curvature, Frenet equations, local classification, submanifolds in Euclidean spaces, in particular hypersurfaces, curvature of hypersurfaces, geodesics, isometries, main theorem on local surface theory, special classes of surfaces) or

**Projective Geometry** (projective and affine planes, theorem of Desargues, fundamental theorems for projective spaces, dualities and polarities of projective spaces).

**Intended learning outcomes**

The student is acquainted with fundamental concepts and methods in algebra and geometry (differential geometry or projective geometry). He/She is able to relate these concepts with one another, and realises the advantages of thinking across the borders of different branches in mathematics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

oral examination of one candidate each (20 to 40 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Overview Stochastics and Applied Mathematics (Numerical Mathematics 1 or Discrete Mathematics) for Teaching Degree (German Gymnasium)</td>
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**Contents**

**Stochastics** (discrete stochastics, in particular stochastic modelling, motivation of conceptualisation and discussion of basic assumptions: basic notions of descriptive statistics, discrete probability spaces, random variables, important discrete distributions, elements of combinatorics, principle of inclusion and exclusion, multistage experiments, conditional probability, stochastic independence, common distributions, expected value and variance, covariance and correlation, waiting time problems, law of the large numbers, central limit theorem, confidence intervals and statistical tests in binomial models, stochastical paradoxes)

and either

**Numerical Mathematics 1** (solution of systems of linear equations and curve fitting problems, nonlinear equations and systems of equations, interpolation with polynomials, splines and trigonometric functions, numerical integration)

or

**Discrete Mathematics** (techniques from combinatorics, introduction to graph theory including applications, cryptographic methods, error-correcting codes).

**Intended learning outcomes**

The student is acquainted with fundamental concepts and methods in stochastics and a further topic in applied mathematics (numerical mathematics or discrete mathematics). He/She is able to relate these concepts with one another, and realises the advantages of thinking across the borders of different branches in mathematics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

oral examination of one candidate each (20 to 40 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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## Giovanni Prodi Lecture (Master)

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### Contents

Introduction to a specialised topic in mathematics by an international expert.

### Intended learning outcomes

The student is acquainted with the fundamental concepts and methods of a contemporary research topic in mathematics. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and applications in other subjects.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)

Module taught in: German and/or English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 60 to 90 minutes, usually chosen) or b) oral examination of one candidate each (approx. 15 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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### Contents
Introduction to a specialised topic in mathematics by an international expert.

### Intended learning outcomes
The student is acquainted with the fundamental concepts and methods of a contemporary research topic in mathematics. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and applications in other subjects.

### Courses (type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)  
Module taught in: German and/or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen)  
b) oral examination of one candidate each (approx. 20 minutes)  
c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester  
Language of assessment: German or English  
Creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO 1 (examination regulations for teaching-degree programmes)
--
**Module title**  
Giovanni Prodi Lecture Advanced Topics (Master)

**Abbreviation**  
10-M=VGPA-161-m01

**Module coordinator**  
Dean of Studies Mathematik (Mathematics)

**Module offered by**  
Institute of Mathematics

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**Method of grading**  
Only after succ. compl. of module(s)

**Duration**  
1 semester

**Module level**  
graduate

**Contents**

Introduction to a specialised topic in mathematics by an international expert.

**Intended learning outcomes**

The student is acquainted with the fundamental concepts and methods of a contemporary research topic in mathematics. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and applications in other subjects.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen)  
b) oral examination of one candidate each (approx. 20 minutes)  
c) oral examination in groups (groups of 2, 15 minutes per candidate)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title
Giovanni Prodi Lecture Modern Topics (Master)

### Abbreviation
10-M=VGP1-161-m01

### Module coordinator
Dean of Studies Mathematik (Mathematics)

### Module offered by
Institute of Mathematics

### ECTS
10

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

### Contents
Introduction to a specialised topic in mathematics by an international expert.

### Intended learning outcomes
The student is acquainted with the fundamental concepts and methods of a contemporary research topic in mathematics. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and applications in other subjects.

### Courses
(type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)
Module taught in: German and/or English

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 120 minutes, usually chosen) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, 15 minutes per candidate)
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German or English
creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)
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<td>1 semester</td>
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</table>

**Contents**

A modern topic in the research expertise of the current holder of the Giovanni Prodi Chair.

**Intended learning outcomes**

The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

talk (60 to 120 minutes)

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module title: Theoretical Physics 1 for Pre Service Teachers

Abbreviation: 11-L-T1-161-m01

Module coordinator: Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by: Faculty of Physics and Astronomy

ECTS: 7

Method of grading: numerical grade

Duration: 1 semester

Module level: undergraduate

Other prerequisites: Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.

Contents:
Physical laws and elementary methods of Theoretical Physics. Mechanics: Newton’s laws, physical values and conservation laws, systems of mass points, reference systems, one-dimensional motion, Lagrange equations, applications, Hamiltonian dynamics.
Quantum mechanics: Schrödinger equation, one-dimensional quantum mechanics, abstract quantum mechanics (operator formalism), angular momentum, spin.
Electrodynamics: Maxwell equations, electrostatics, magnetostatics, dynamics of electromagnetic fields, special relativity.
Thermodynamics: Heat, entropy, thermal equilibrium, measurands, level of efficiency, thermodynamic potentials, phase transitions

Intended learning outcomes:
The students know the basic principles, contexts and elementary methods of Theoretical Physics, theoretical mechanics, quantum mechanics, thermodynamics, electrodynamics and Statistical Physics. They are able to discuss the acquired theoretical concepts and to attribute them to bigger physical contexts.

Courses (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)
Module taught in: Ü: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
written examination (approx. 120 minutes)
Language of assessment: German and/or English

Allocation of places
--

Additional information:
Registration: If a student registers for the exercises or the seminar and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student’s registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.

Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Module title
**Theoretical Physics 2 for Pre Service Teachers - Exercises**

### Abbreviation
11-L-T2-161-m01

### Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

### Module offered by
Faculty of Physics and Astronomy

### ECTS
7

### Method of grading
Only after succ. compl. of module(s)

### Duration
1 semester

### Module level
undergraduate

### Other prerequisites
Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.

### Contents
Exercises in theoretical mechanics, quantum mechanics, Statistical Physics, thermodynamics and electrodynamics. Among others: Newton’s laws, physical quantities and conservation laws, systems of mass points, reference systems, one-dimensional motion, Lagrange equations, applications, Hamiltonian dynamics; Schrödinger equation, one-dimensional quantum mechanics, abstract quantum mechanics (operator formalism), angular momentum, spin, Maxwell equations, electrostatics, magnetostatics, dynamic electromagnetic fields, special theory of relativity; heat, entropy, thermal equilibrium, measured variables, efficiency, thermodynamic potentials, phase transitions

### Intended learning outcomes
The students are able to independently apply the methods of Theoretical Physics to the solution of problems of theoretical mechanics, quantum mechanics, thermodynamics, electrodynamics and Statistical Physics and to interpret the solutions.

### Courses (type, number of weekly contact hours, language — if other than German)
**V (4) + Ü (2)**
Module taught in: Ü: German or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
oral examination of one candidate each (approx. 30 minutes)
Assessment will have reference to the contents of modules 11-L-T1 and 11-L-T2.
Language of assessment: German and/or English

### Allocation of places
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### Additional information
Registration: If a student registers for the exercises or the seminar and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student’s registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.

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**Contents**

The students acquire subject-didactic competencies which exceed the requirements of the teaching degree programme. The module especially focuses on subject-didactic research methods and on the examination of current international subject-didactic research. Most of the lectures combine topics of various disciplines. In addition, they establish connections to scientific disciplines and educational sciences. Some exemplary topics might be: Qualitative and quantitative research methods in subject didactics; connections between subject didactics and educational sciences; interdisciplinary connections between subject didactics and scientific disciplines; closer connections between subject didactics and school practice; in-depth analyses of classes (e.g. video studies, "university classroom"); exploratory learning at extracurricular learning facilities (e.g. genetic engineering laboratory in Bayreuth, teaching-learning-laboratories (LLL); M!ND and SFZ (special needs centre), M!ND in Würzburg)

**Intended learning outcomes**

In-depth study of subject didactics; interdisciplinary connections; in-depth analyses of classes; connection of scientific disciplines, subject didactics, school practice and educational sciences.

**Courses** *(type, number of weekly contact hours, language — if other than German)*

V (2) + Ü (1)
Module taught in: German and/or English
Course type: alternatively S (2) or P (2) instead of Ü (1)

**Method of assessment** *(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)*

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (20 to 40 minutes) or c) talk (30 to 60 minutes) or d) practical assignment including report (approx. 10 to 20 pages) and talk (approx. 15 minutes) or e) term paper (approx. 15 to 25 pages, usually chosen)
Language of assessment: German and/or English creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** *(examination regulations for teaching-degree programmes)*

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Module title: Advanced Subject Didactics 2  
Abbreviation: MINT-B2-162-m01

Module coordinator: Chair of MIND Center  
Module offered by: M!nd-Center

ECTS: 5  
Method of grading: numerical grade  
Only after succ. compl. of module(s): --

Duration: 1 semester  
Module level: graduate  
Other prerequisites: --

Contents:
The students acquire subject-didactic competencies which exceed the requirements of the teaching degree programme. The module especially focuses on subject-didactic research methods and on the examination of current international subject-didactic research. Most of the lectures combine topics of various disciplines. In addition, they establish connections to scientific disciplines and educational sciences. Some exemplary topics might be: Qualitative and quantitative research methods in subject didactics; connections between subject didactics and educational sciences; interdisciplinary connections between subject didactics and scientific disciplines; closer connections between subject didactics and school practice; in-depth analyses of classes (e.g. video studies, "university classroom"); exploratory learning at extracurricular learning facilities (e.g. genetic engineering laboratory in Bayreuth, teaching-learning-laboratories (LLL); M!ND and SFZ (special needs centre), MIND in Würzburg)

Intended learning outcomes:
In-depth study of subject didactics; interdisciplinary connections; in-depth analyses of subject didactics, school practice and educational sciences.

Courses (type, number of weekly contact hours, language — if other than German):
V (2) + Ü (1)  
Module taught in: German and/or English  
Course type: alternatively S (2) or P (2) instead of Ü (1)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus):
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (20 to 40 minutes) or c) talk (30 to 60 minutes) or d) practical assignment including report (approx. 10 to 20 pages) and talk (approx. 15 minutes) or e) term paper (approx. 15 to 25 pages, usually chosen)
Language of assessment: German and/or English credible for bonus

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
--
Module title: Research in Groups
Abbreviation: MINT-C1-162-m01

Module coordinator: Chair of MIND Center
Module offered by: M!nd-Center

ECTS: 5
Method of grading: Only after succ. compl. of module(s)

Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents
The students examine international research in an interdisciplinary manner and study current research areas of scientific disciplines and/or subject didactics in order to advance their competencies acquired in the module areas A and B. The module also includes courses offered by external guest researchers. The specific forms of teaching and the university-didactic concept of "exploratory learning" especially promote advanced professional skills and transferable skills for scientific work.

Intended learning outcomes
Participation in/implementation of qualitative and quantitative research projects; scientific work; interdisciplinary research

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (1)
Module taught in: German and/or English
Course type: alternatively S (2) or P (2) instead of Ü (1)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (20 to 40 minutes) or c) talk (30 to 60 minutes) or d) practical assignment including report (approx. 10 to 20 pages) and talk (approx. 15 minutes) or e) term paper (approx. 15 to 25 pages, usually chosen)
Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Scientific Internship</td>
<td>MINT-C2-162-m01</td>
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<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
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<tbody>
<tr>
<td>Chair of MIND Center</td>
<td>MInd-Center</td>
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<tr>
<th>ECTS</th>
<th>Method of grading</th>
<th>Only after succ. compl. of module(s)</th>
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<tbody>
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<tr>
<th>Duration</th>
<th>Module level</th>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</tbody>
</table>

**Contents**

The students examine international research in an interdisciplinary manner and study current research areas of scientific disciplines and/or subject didactics in order to advance their competencies acquired in the module areas A and B. The module also includes courses offered by external guest researchers. The specific forms of teaching and the university-didactic concept of "exploratory learning" especially promote advanced professional skills and transferable skills for scientific work.

**Intended learning outcomes**

Research placements at university and non-university research institutions; scientific work; interdisciplinary research.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1)

Module taught in: German and/or English

Course type: alternatively S (2) or P (2) instead of Ü (1)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (20 to 40 minutes) or c) talk (30 to 60 minutes) or d) practical assignment including report (approx. 10 to 20 pages) and talk (approx. 15 minutes) or e) term paper (approx. 15 to 25 pages, usually chosen)

Language of assessment: German and/or English

creditable for bonus

**Allocation of places**

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**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
**Module title**

Key Competences for Teaching Professions 1

**Abbreviation**

MINT-D1-162-m01

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**Module coordinator**

Chair of M!ND Center

**Module offered by**

M!nd-Center

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**ECTS**

5

**Method of grading**

(only after successfully completed)

**Duration**

1 semester

**Module level**

graduate

---

**Contents**

In the elite programme, the participants have the opportunity to improve key competencies which are of specific importance for occupations in the area of education and science. These competencies include: Intercultural competence (conscious approach to cultural differences); legal expertise and organisational competence (legal framework of educational institutions, sensitive approach to organisational problems); media competence (creating multimedia products for education processes, media analysis, evaluation of the effects of media); personal and social competence (personal qualities such as self-confidence, the ability to take criticism, a sense of responsibility and moral concepts); communication competence (especially communication in the educational and science system); ethical evaluation of science (moral standards of science, ethical framework conditions of science, philosophical aspects of STEM subjects)

---

**Intended learning outcomes**

Legal expertise and organisational competence; media competence; personal and social competence; personal qualities such as self-confidence, the ability to take criticism, a sense of responsibility and moral concepts; communication competence, ethical evaluation of science

---

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1)

Module taught in: German and/or English

Course type: alternatively S (2) or P (2) instead of Ü (1)

---

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (20 to 40 minutes) or c) talk (30 to 60 minutes) or d) practical assignment including report (approx. 10 to 20 pages) and talk (approx. 15 minutes) or e) term paper (approx. 15 to 25 pages, usually chosen)

Language of assessment: German and/or English creditable for bonus

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**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

--
Key Competences for Teaching Professions 2

**Module title**

**Abbreviation**

MINT-D2-162-m01

**Module coordinator**

Chair of MIND Center

**Module offered by**

Mind-Center

**ECTS**

5

**Method of grading**

Only after succ. compl. of module(s)

**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

--

**Contents**

In the elite programme, the participants have the opportunity to improve key competencies which are of specific importance for occupations in the area of education and science. These competencies include: Intercultural competence (conscious approach to cultural differences); legal expertise and organisational competence (legal framework of educational institutions, sensitive approach to organisational problems); media competence (creating multimedia products for education processes, media analysis, evaluation of the effects of media); personal and social competence (personal qualities such as self-confidence, the ability to take criticism, a sense of responsibility and moral concepts); communication competence (especially communication in the educational and science system); ethical evaluation of science (moral standards of science, ethical framework conditions of science, philosophical aspects of STEM subjects)

**Intended learning outcomes**

Legal expertise and organisational competence; media competence; personal and social competence; personal qualities such as self-confidence, the ability to take criticism, a sense of responsibility and moral concepts; communication competence, ethical evaluation of science

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1)

Module taught in: German and/or English

Course type: alternatively S (2) or P (2) instead of Ü (1)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (20 to 40 minutes) or c) talk (30 to 60 minutes) or d) practical assignment including report (approx. 10 to 20 pages) and talk (approx. 15 minutes) or e) term paper (approx. 15 to 25 pages, usually chosen)

Language of assessment: German and/or English

Creditable for bonus

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I**

(examination regulations for teaching-degree programmes)
### Module title

**Master-Thesis**

### Abbreviation

MINT-MA-162-m01

### Module coordinator

Chair of MIND Center

### Module offered by

Centre for Teacher Training and Educational Research (ZfL)

### ECTS

30

### Method of grading

numerical grade

### Only after succ. compl. of module(s)

--

### Duration

graduate

### Module level

--

### Other prerequisites

--

### Contents

The students carry out independent research to examine a complex question for their Master's thesis. In doing so, they are allowed to flexibly set their own priorities. All work groups of the subjects involved of both universities are available for the supervision of the Master’s thesis. Therefore, the students can also write their Master's theses in an inter-university manner. They are integrated into research projects of the corresponding work groups. This enables them to experience how current research is almost always conducted in (inter-)national cooperation.

### Intended learning outcomes

Writing and publishing scientific works; applied research; scientific examination of subject-specific, subject-didactic and/or educational-scientific topics

### Courses

(type, number of weekly contact hours, language — if other than German)

No courses assigned to module

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

Master's thesis (approx. 60 pages)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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Module title
Advanced Magnetic Resonance Imaging

Abbreviation
11-MRI-171-m01

Module coordinator
Managing Director of the Institute of Applied Physics

Module offered by
Faculty of Physics and Astronomy

ECTS
6

Method of grading
numerical grade

Duration
1 semester

Module level
graduate

Other prerequisites
--

Contents
Nuclear magnetic resonance (NMR) is a quantum mechanical phenomenon that, through magnetic resonance imaging (MRI), has played a major role in the revolution of medical imaging over the last 30 years. Based on the fundamental principles of nuclear magnetic resonance (resonance principle, relaxation times, chemical shift) this course covers:
1) the NMR signal theory and signal evolution (Bloch equations),
2) the principles of spatial encoding, magnetic resonance imaging (MRI) and corresponding imaging sequences and measurement parameters,
3) the concept of k-space and Fourier imaging, and
4) the physical, methodological and technical possibilities and limits of MRI. As a last point, exemplary application fields of MRI of biomedical research, clinical imaging and non-destructive testing are introduced.

Intended learning outcomes
The students have advanced knowledge of the mathematical-theoretical and physical principles of modern imaging magnetic resonance, image generation and processing. They gain a broad overview of the field of modern MRI and its interdisciplinary contexts and applications.

Courses (type, number of weekly contact hours, language — if other than German)
V (3) + R (1)
Module taught in: English

In the semester in which the course is offered and in the subsequent semester

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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<table>
<thead>
<tr>
<th>Module title</th>
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<tbody>
<tr>
<td>String Theory 1</td>
<td>11-STRG1-171-m01</td>
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</table>

**Module coordinator**

Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**

Faculty of Physics and Astronomy

<table>
<thead>
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<th>ECTS</th>
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<tbody>
<tr>
<td>8</td>
<td>numerical grade</td>
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</tbody>
</table>

**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

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**Contents**

Classical and quantum theory of the relativistic bosonic string, in particular the Nambu-Goto action and Polyakov action; quantisation of the closed bosonic string and emergent graviton; quantum Lorentz invariance and critical dimension; quantisation of the open bosonic string, D-Branes, Gauge Fields and Yang-Mills theories; relativistic conformal field theory, string path integral, BRST quantisation, string interactions, effective actions and gravity.

**Intended learning outcomes**

The students are familiar with classical and quantum theory of relativistic bosonic strings. They know the classical actions for relativistic bosonic strings, the Nambu-Goto action and Polyakov action, they have quantised the bosonic string and understand the emergence of the massless graviton in the spectrum of the closed string. They have calculated Lorentz anomaly on quantum level to deduce the critical dimension of the bosonic string. They understand the boundary conditions for the open string and its connection to D-branes. They have knowledge of open string quantisation and of the spectrum of massless gauge fields, as well as of Yang-Mills fields for coincident branes. They are familiar with relativistic conformal field theory, the string path integral, its BRST quantisation and the calculation of string interactions. They understand the low-energy effective actions in target space and the emergence of Einstein gravity.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (4) + R (2)

Module taught in: German or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module title | Abbreviation
---|---
String Theory 2 | 11-STRG2-171-m01

Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
---|---|---
6 | numerical grade | --

Duration | Module level | Other prerequisites
---|---|---
1 semester | graduate | --

Contents

Superstring theories and M theory, in particular a short introduction to bosonic string theory, the theory of fermionic fields and representations of Clifford algebra in diverse dimensions, a review of supersymmetry in two and more dimensions, the classical and quantum version of the Ramond-Neveu-Schwarz superstring, type II A/B superstrings, the Gliozzi-Scherck-Olive projection and space-time supersymmetry in 10 dimensions, the type I superstring, heterotic string theories, anomaly cancellation and restrictions on gauge groups, dualities between the five superstring theories as well as their relation to M theory in 11D, D-Branes and supersymmetric gauge theories, supergravity and the AdS/CFT correspondence.

Intended learning outcomes

The students are familiar with supersymmetrical string theory and M theory. They know the basic characteristics of bosonic string theory and fermionic field theory as well as the depiction of Clifford algebra in different dimensions. They have studied the aspects of supersymmetry in two or more dimensions relevant to superstring theory. They are acquainted with classical and quantum theory of the Ramon-Neveu-Schwarz superstring, they understand the deduction of type IIA/B string theories and the ensuring of space-time supersymmetry on the basis of Gliozzi-Scherk-Olive projection. They have gained insights into type I and heterotic superstring theory and into the limiting effects of anomaly freedom on the permitted gauge groups of these theories. They have studied the dualities between the five superstring theories and their connections to M theory in 11 dimensions. They are familiar with the properties of supersymmetric D-branes in type I and II superstring theories and the corresponding supersymmetric gauge theories as well as the supergravity effects in 10 and 11 dimensions and the connection to AdS/CFT correspondence.

Courses (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Module title: Surface Science
Abbreviation: 11-SSC-172-m01

Module coordinator: Managing Director of the Institute of Applied Physics
Module offered by: Faculty of Physics and Astronomy

ECTS: 6
Method of grading: Only after succ. compl. of module(s)

Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:

Intended learning outcomes:
The students have gained an overview of the diverse aspects of surface physics and especially know the causes and contexts of physical peculiarities of surfaces and interfaces. Additionally, they know the most important experimental techniques and their specific application possibilities in the context of surface physics.

Courses:
(type, number of weekly contact hours, language — if other than German)
V (3) + R (1)
Module taught in: Englisch

Method of assessment:
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: In the semester in which the course is offered and in the subsequent semester.
Language of assessment: German and/or English

Allocation of places:
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Additional information:
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<th>Abbreviation</th>
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<tr>
<td>Modern Aspects of Natural Product Chemistry and Biological Chemistry</td>
<td>08-OCM-NAT-172-m01</td>
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<tbody>
<tr>
<td>lecturer of the seminar</td>
<td>Institute of Organic Chemistry</td>
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<tr>
<th>Duration</th>
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<tbody>
<tr>
<td>1 semester</td>
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</table>

**Contents**

The module provides practical skills in the fields of recombinant engineering and characterization of macromolecular complexes, current biomolecular techniques, analysis of biochemical processes in vivo, and up-to-date imaging techniques.

**Intended learning outcomes**

The student has knowledge of molecular biology and is able to apply the contents in practical experiments.

**Courses** (type, number of weekly contact hours, language — if other than German)

S

/Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 45 to 90 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (15 to 30 minutes per candidate)

Language of assessment: German and/or English

**Allocation of places**

Master’s degree programme Chemie (Chemistry): no limitation. Master’s degree programme Biochemie (Biochemistry): 20 places. Places will be allocated according to the number of subject semesters; among applicants with the same number of subject semesters, places will be allocated by lot. A waiting list will be maintained and places re-allocated as they become available.

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Molecular Biology laboratory course

**Abbreviation**: 08-BC-MOLP-172-m01

**Module coordinator**: holder of the Chair of Biochemistry

**Module offered by**: Chair of Biochemistry

**ECTS**: 10

**Method of grading**: numerical grade

**Duration**: 1 semester

**Module level**: undergraduate

**Other prerequisites**: --

**Contents**

German contents available but not translated yet.


**Intended learning outcomes**

The student masters theoretical and experimental methods and aspects of drug design.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (5)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

a) written examination (approx. 45 to 90 minutes) or b) log (10 to 20 pages) or c) oral examination of one candidate each (20 to 30 minutes) or d) oral examination in groups of up to 3 candidates (approx. 15 to 20 minutes per candidate) or e) presentation (20 to 30 minutes) or f) practical examination (on average approx. 2 hours; time to complete will vary according to subject area but will not exceed a maximum of 4 hours)

Assessment offered: Once a year, winter semester

Language of assessment: German and/or English

**Allocation of places**

Biochemie (Biochemistry) 24 places. Selection process Biochemie (Biochemistry), Bachelor's (180 ECTS credits): Should the number of applications exceed the number of available places, places will be allocated according to the following quotas: Quota 1 (two thirds of places): current average grade of successfully completed modules; among applicants with the same average grade, places will be allocated by lot. Quota 2 (one third of places): number of subject semesters of the respective applicant; among applicants with the same number of subject semesters, places will be allocated by lot. A waiting list will be maintained and places re-allocated as they become available.

Chemie (Chemistry), Master's and MINT-Lehramt PLUS Master's: 6 places. Selection process: 1. Applications of Master's degree programme Chemie (Chemistry) (120 ECTS credits) will be considered first: Places will be allocated according to the number of subject semesters. Among applicants with the same number of subject semesters, places will be allocated by lot. A waiting list will be maintained and places re-allocated by lot as they become available. 2. In case that there are places left after procedure 1 is finished completely, theses places will be distributed among the students in the Master's degree programme MINT-Lehramt PLUS as follows: Places will be allocated according to the number of subject semesters. Among applicants with the same number of subject semesters, places will be allocated by lot. A waiting list will be maintained and places re-allocated by lot as they become available.

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
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<td>08-MCM3-172-m01</td>
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<tr>
<td>lecturers Pharmazeutische Chemie (Pharmaceutical Chemistry)</td>
<td>Institute of Pharmacy and Food Chemistry</td>
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</table>

**Contents**

German contents available but not translated yet.

Das Modul behandelt spezielle Themen der Naturstoffchemie und Biologischer Chemie.

**Intended learning outcomes**

German intended learning outcomes available but not translated yet.

Die Studierenden können spezifische Themen der Naturstoffchemie und Biologischer Chemie erklären.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)

presentation (approx. 30 minutes) with discussion

Language of assessment: German and/or English

**Allocation of places**

22 places. 16 places for students of the Master’s degree programme Chemie (Chemistry): Places will be allocated according to the same number of subject semesters; students who have chosen Medizinische Chemie (Medical Chemistry) as their focus will be given preferential consideration. 6 places for students of the Master’s degree programme Biochemie (Biochemistry): Places will be allocated according to the number of subject semesters; among applicants with the same number of subject semesters, places will be allocated by lot. 2 places for students of the Master’s degree programme MINT-Lehramt PLUS: Places will be allocated according to the number of subject semesters; among applicants with the same number of subject semesters, places will be allocated by lot; a waiting list will be maintained and places re-allocated by lot as they become available.

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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