Module Catalogue
for the Subject
Mathematics
as a Master’s with 1 major
with the degree "Master of Science"
(120 ECTS credits)

Examination regulations version: 2012
Responsible: Institute of Mathematics
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The subject is divided into

Content and Objectives of the Programme

Abbreviations used, Conventions, Notes, In accordance with

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Differential Geometry
Complex Analysis
Geometric Structures
Industrial Statistics 1
Lie Theory
Numeric of large Systems of Equations
Basics of Optimization
Introduction to Control Theory
Stochastic Models for Risk Analysis
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Time Series Analysis 1
Number Theory
Giovanni-Prodi Lecture (Master)

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Content and Objectives of the Programme

The mathematics Master programme is offered by the Department of Mathematics, with a total of currently (SS 2010) 9 chairs.

The Masters study programme in mathematics is intended to provide the students with the following abilities.
- capacity of abstraction,
- exactness in analytic reasoning,
- excellent capacity to realize the structure of complex interconnections,
- sound qualification in applying mathematical methods to specific problems,
- insight into the intrinsic mathematical interdependence of different mathematical fields, as well as into interdisciplinary connections,
- high stamina in dealing with difficult problems,
- high competence in problem solving,
- ability to carry out independent scientific work on a high level,
- ability to cooperate as responsible mathematician within an interdisciplinary team of mathematicians, computer scientists, natural scientists, engineers, or specialists in economical sciences and entrepreneurship,
- insight into and overview over current research in at least one field of contemporary mathematics,
- qualification for meeting the standards of a Ph.D. study in mathematics (if applicable).

For the Master thesis the student should work on a thematic and temporally closely limited frame in order to carry out independently a mathematical task, using well-known procedures and scientific criteria, or modifying them if necessary.

The Masters exam should ascertain whether the candidate overlooks the context of the basics in mathematics and possesses the ability to use the corresponding scientific methods, achieving in this way a further professional and/or scientific qualification.
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:

ASPO2009

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

28-Nov-2012 (2012-197)

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.
Mathematics
(60-90 ECTS credits)
Advanced Programme
(15-65 ECTS credits)
### Module Catalogue for the Subject Mathematics

**Master's with 1 major, 120 ECTS credits**

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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

- **V + Ü** (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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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**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**

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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
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
- V + Ü (no information on SWS (weekly contact hours) and course language available)

#### Method of assessment
At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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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# Complex Analysis

## Abbreviation
10-M=AFTH-102-m01

## Module coordinator
Dean of Studies Mathematik (Mathematics)

## Module offered by
Institute of Mathematics

## ECTS
10

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

## Duration
1 semester

## Module level
graduate

## Other prerequisites
Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

## 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
(V + Ü (no information on SWS (weekly contact hours) and course language available)

## Method of assessment
At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (go to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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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### Geometric Structures

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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
Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### 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

(V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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
---|---
Industrial Statistics 1 | 10-M=AIST-102-m01

Module coordinator | Module offered by
Dean of Studies Mathematik (Mathematics) | Institute of Mathematics

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Duration | Module level | Other prerequisites
1 semester | graduate | Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

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 + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)
Language of assessment: German, 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

**ECTS**

10

**Method of grading**

Numerical grade

**Duration**

1 semester

**Module level**

Graduate

**Other prerequisites**

Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

**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**

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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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Numeric of large Systems of Equations | 10-M-ANGG-102-m01

Module coordinator | Module offered by
Dean of Studies Mathematik (Mathematics) | Institute of Mathematics

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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 + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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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<td>Basics of Optimization</td>
<td>10-M=AOPT-102-m01</td>
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<td>Dean of Studies Mathematik (Mathematics)</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

V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (go to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)  
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.  
Language of assessment: German, 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 Control Theory | 10-M=ARTH-102-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 | graduate | Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment during the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

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 + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
written examination (approx. 90 to 120 minutes); if announced by the lecturer, the written examination can be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups (groups of 2, approx. 30 minutes)
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.
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

**Stochastic Models for Risk Analysis**

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<td>10-M=ASMR-102-m01</td>
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### Module coordinator

Dean of Studies Mathematik (Mathematics)

### Module offered by

Institute of Mathematics

### ECTS

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</table>

### 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

- **V + Ü** (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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

**Stochastical Processes**

### Abbreviation

10-M=ASTP-102-m01

### Module coordinator

Dean of Studies Mathematik (Mathematics)

### Module offered by

Institute of Mathematics

### ECTS

10

### Method of grading

Only after succ. compl. of module(s)

### Duration

1 semester

### Module level

graduate

### Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### 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

V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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: Topology  
Abbreviation: 10-M=ATOP-102-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: Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

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 + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
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Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.  
Language of assessment: German, English

Allocation of places
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Additional information
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<td>Insurance Mathematics</td>
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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, expection 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 + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

- Type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus
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  - Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I

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<td>Time Series Analysis 1</td>
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</table>

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 + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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: Number Theory

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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

<table>
<thead>
<tr>
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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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Module title | Abbreviation
---|---
Giovanni-Prodi Lecture (Master) | 10-M=AGPC-102-m01

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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 + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Language of assessment: English, German if agreed upon with the examiner

Allocation of places

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Additional information

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

--
Specialisation

(15-65 ECTS credits)
Module title
Selected Topics in Analysis

Abbreviation
10-M=VANA-122-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
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

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 + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
At the beginning of the course, the lecturer will choose one of the following methods of assessment: 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 of 2 candidates (approx. 30 minutes total)
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.
Language of assessment: German, 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
Algebraic Topology

### Abbreviation
10-M=VATP-102-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
Homology, homotopy invariance, exact sequences, cohomology, application to the topology of Euclidean spaces.

### Intended learning outcomes
The student is acquainted with advanced results in algebraic topology.

### Courses
V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
At the beginning of the course, the lecturer will choose one of the following methods of assessment: 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 of 2 candidates (approx. 30 minutes total)

Language of assessment: German, 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 Catalogue for the Subject
### Mathematics
#### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Special Topics in Financial Mathematics</td>
<td>10-M=VFNM-102-m01</td>
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<table>
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</tbody>
</table>

### 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
V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
At the beginning of the course, the lecturer will choose one of the following methods of assessment: 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 of 2 candidates (approx. 30 minutes total)

Language of assessment: German, 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
Groups and their Representations

### Abbreviation
10-M=VGDS-102-m01

### 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
Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### 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
V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
At the beginning of the course, the lecturer will choose one of the following methods of assessment: 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 of 2 candidates (approx. 30 minutes total)
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.
Language of assessment: German, 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>Geometrical Mechanics</td>
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### Module coordinator

Dean of Studies Mathematik (Mathematics)  
Institute of Mathematics

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</table>

### Contents

Introduction to geometric mechanics: basic notions of differential geometry and symplectic geometry, Euler-Lagrange equations, Hamiltonian mechanics on manifolds.

### Intended learning outcomes

The student is able to apply fundamental methods and concepts of geometry to problems in mechanics, and knows about the interrelation of these fields.

### Courses

(V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

At the beginning of the course, the lecturer will choose one of the following methods of assessment: 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 of 2 candidates (approx. 30 minutes total)  
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

### Language of assessment

German, 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: Industrial Statistics 2

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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

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

V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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)
### Field Arithmetic

**Module title**  
Field Arithmetic

**Abbreviation**  
10-M=VKAR-102-m01

**Module coordinator**
Dean of Studies Mathematik (Mathematics)

**Module offered by**
Institute of Mathematics

**ECTS**
10

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

**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### 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
V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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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Giovanni-Prodi Lecture Selected Topics (Master) | 10-M=VGPC-122-m01

Module coordinator | Module offered by
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Dean of Studies Mathematik (Mathematics) | Institute of Mathematics

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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/Shi is able to establish a connection between his/her acquired skills and other branches of mathematics and applications in other subjects.

Courses
V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment
At the beginning of the course, the lecturer will choose one of the following methods of assessment: 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 of 2 candidates (approx. 30 minutes total)
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.
Language of assessment: English, German if agreed upon with the examiner

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)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

**Language of assessment:** German, 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 Catalogue for the Subject Mathematics

**Master's with 1 major, 120 ECTS credits**

<table>
<thead>
<tr>
<th>Module title</th>
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<tbody>
<tr>
<td>Selected Topics in Optimization</td>
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</table>

### 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

V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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
---|---
Statistical Analysis | 10-M=VSTA-102-m01

Module coordinator | Module offered by
Dean of Studies Mathematik (Mathematics) | Institute of Mathematics

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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
V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment
At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)
Language of assessment: German, 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

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

V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (go to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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: Time Series Analysis 2
Abbreviation: 10-M=VZRA-102-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:
Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g., successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

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:
V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment:
At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)
Language of assessment: German, 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
--- | ---
Discrete Mathematics | 10-M=VDIM-102-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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5 | numerical grade | -- |

| Duration | Module level | Other prerequisites |
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1 semester | graduate | Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew. |

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 + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.
Language of assessment: German, English

Allocation of places

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Additional information

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<td>Dynamical Systems and Control</td>
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</tr>
</tbody>
</table>

Contents

Basics in dynamical systems and control: non-linear dynamics, stability theory, ergodic theory, Hamiltonian systems; selected advanced topics, e.g. networked dynamical systems, non-linear stability, dynamics with restricted communication, entropy of dynamical systems.

Intended learning outcomes

The student masters the mathematical methods in the theory of dynamic systems and control, and is able to analyse their quality.

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

V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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
Aspects of Geometry

### Abbreviation
10-M=VGEO-102-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
Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### 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
\( V + Ü \) (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
(type, scope, language — if other than German)
At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)
Language of assessment: German, 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
--- | ---
Basics in Mathematics | 10-M=VGRM-102-m01

Module coordinator | Module offered by
Dean of Studies Mathematik (Mathematics) | Institute of Mathematics

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Duration | Module level | Other prerequisites
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1 semester | graduate | Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
Discussion of problems and questions on the foundation of mathematics, applying methods of set theory, logic and philosophy.

Intended learning outcomes
The student is acquainted with the foundational methods in mathematics and logic.

Courses (type, number of weekly contact hours, language — if other than German)
V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)
Language of assessment: German, 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
Mathematical Continuum Mechanics

### Abbreviation
10-M=VKOM-122-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
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### 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
(V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
( at the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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: Mathematical Imaging
Abbreviation: 10-M=VMBV-102-m01

Module coordinator: Dean of Studies Mathematik (Mathematics)
Module offered by: Institute of Mathematics

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

Duration: 1 semester
Module level: graduate
Other prerequisites:
Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

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:
V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment:
At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)
Language of assessment: German, 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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Selected Topics in Mathematical Physics

Module title | Abbreviation
---|---
Selected Topics in Mathematical Physics | 10-M=VMPH-102-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 | Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e.g., successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
Selected topics in mathematical physics (e.g. differential equations of mathematical physics, probability theory, hydrodynamics, hyperbolic conservation equations, mathematical materials science, quantum mechanics).

Intended learning outcomes
The student is acquainted with advanced results in a field in mathematical physics. He/She knows mathematical methods in mathematical physics and can apply them to solve problems in physics.

Courses (type, number of weekly contact hours, language — if other than German)
V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.
Language of assessment: German, 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 Catalogue for the Subject Mathematics
## Master’s with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tr>
<td>Modul Theory</td>
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</table>

**Contents**

Basics in module theory: modules and module spaces, canonical decomposition and representations, simple, semi-simple and complex modules, module trees and their defibrations, distortion theorems, reduction theorems.

**Intended learning outcomes**

The student masters mathematical methods in module theory and is able to analyse their quality.

**Courses**

<table>
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<tr>
<th>V + Ü (no information on SWS (weekly contact hours) and course language available)</th>
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</table>

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Language of assessment: German, 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
---|---
Non-Linear Analysis | 10-M=VNAN-102-m01

<table>
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</table>

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

<table>
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<tr>
<th>type</th>
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Method of assessment

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Language of assessment: German, 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
---|---
Optimal Control | 10-M=VOST-102-m01

Module coordinator | Module offered by
Dean of Studies Mathematik (Mathematics) | Institute of Mathematics

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**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

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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**

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Language of assessment: German, 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**

Basics in dynamics of quantum-mechanical systems (e.g. density operators, observables, Schrödinger equation, Liouville-von-Neumann equation), bilinear control systems in quantum mechanics (e.g. finite-dimensional spin systems and/or infinite-dimensional Schrödinger equations with external control), applications (e.g. in quantum computing or magnetic resonance spectroscopy).

**Intended learning outcomes**

The student is acquainted with advanced methods in quantum-mechanical control systems. He gains the ability to work on contemporary research questions in and applications of control systems in quantum mechanics.

**Courses**

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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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</table>

**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 + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Language of assessment: German, 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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Workshops and Seminars
(10-60 ECTS credits)
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<th>Abbreviation</th>
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<td>Study Group Algebra</td>
<td>10-M=GALG-102-m01</td>
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<tbody>
<tr>
<td>1 semester</td>
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<td>Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.</td>
</tr>
</tbody>
</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 + S (no information on SWS (weekly contact hours) and course language available)  

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes)  
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.  
Language of assessment: German, 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 Catalogue for the Subject
Mathematics
Master's with 1 major, 120 ECTS credits

<table>
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<tr>
<th>Module title</th>
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<tbody>
<tr>
<td>Study Group Discrete Mathematics</td>
<td>10-M=GDIM-102-m01</td>
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<tr>
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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 + S (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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
Study Group Dynamical Systems and Control

Abbreviation
10-M=GDSR-102-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
Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

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 + S (no information on SWS (weekly contact hours) and course language available)

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Language of assessment: German, English

Allocation of places
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Additional information
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<td>Study Group Complex Analysis</td>
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</table>

**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**

(V + S (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, English

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

--
### Module title
Study Group Geometry and Topology

### Abbreviation
10-M=GGMT-102-m01

### Module coordinator
Dean of Studies Mathematik (Mathematics)

### Module offered by
Institute of Mathematics

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### Duration
1 semester

### Module level
graduate

### Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

### 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 + S (no information on SWS (weekly contact hours) and course language available)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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)
--
## Study Group Mathematics in its Context

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<th>Module title</th>
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<tbody>
<tr>
<td>Study Group Mathematics in its Context</td>
<td>10-M=GMKX-102-m01</td>
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### Module coordinator

Dean of Studies Mathematik (Mathematics)

### Module offered by

Institute of Mathematics

### ECTS

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### Duration

1 semester

### Module level

Graduate

### Other prerequisites

Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

### 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 + S (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, 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: Study Group Mathematics in the Sciences
Abbreviation: 10-M-GMNW-122-m01

Module coordinator: Dean of Studies Mathematik (Mathematics)
Module offered by: Institute of Mathematics
ECTS: 10
Method of grading: numerical grade

Duration: 1 semester
Module level: graduate

Other prerequisites:
Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

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:
V + S (no information on SWS (weekly contact hours) and course language available)

Method of assessment:
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups of 2 candidates (approx. 30 minutes)
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.
Language of assessment: German, English

Allocation of places:

Additional information:

Referred to in LPO I (examination regulations for teaching-degree programmes):
Module title: Study Group Measure and Integral
Abbreviation: 10-M=GMUI-102-m01

Module coordinator: Dean of Studies Mathematic (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: Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

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 + S (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
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Language of assessment: German, English

Allocation of places:
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Additional information:
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<td>Study Group Numerical Mathematics and Applied Analysis</td>
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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)

V + S (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

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**Language of assessment**: German, English

**Allocation of places**

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**Additional information**

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<tr>
<td>Study Group Robotic, Optimization and Control Theory</td>
<td>10-M=GROK-102-m01</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

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<td>Study Group Statistics</td>
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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 + S (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

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Language of assessment: German, 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 Catalogue for the Subject Mathematics

### Master’s with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
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<tbody>
<tr>
<td>Study Group Time Series Analysis</td>
<td>10-M=GZRA-102-m01</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

<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

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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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## Module Catalogue for the Subject
### Mathematics
#### Master's with 1 major, 120 ECTS credits

<table>
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<tbody>
<tr>
<td>Study Group Number Theory</td>
<td>10-M=GZTH-102-m01</td>
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### Module coordinator

#### Module offered by
- Dean of Studies Mathematik (Mathematics)
- Institute of Mathematics

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### Duration

- 1 semester
- graduate

### Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

### 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

- **V + S (no information on SWS (weekly contact hours) and course language available)**

### Method of assessment

- At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes)
- Language of assessment: German, English

### Allocation of places

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### Additional information

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### Referred to in LPO I

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<td>Seminar in Applied Differential Geometry</td>
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<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean of Studies Mathematik (Mathematics)</td>
<td>Institute of Mathematics</td>
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<tr>
<th>Duration</th>
<th>Module level</th>
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<tr>
<td>1 semester</td>
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<td>Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.</td>
</tr>
</tbody>
</table>

**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 (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.
Language of assessment: German, English

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

--
### Module title
Seminar in Algebra

### Abbreviation
10-M=SALG-102-m01

### 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
Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

### 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 (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.
Language of assessment: German, 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
--- | ---
Seminar in Dynamical Systems and Control | 10-M=SDSR-102-m01

Module coordinator | Module offered by
Dean of Studies Mathematik (Mathematics) | Institute of Mathematics

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Duration | Module level | Other prerequisites
--- | --- | ---
1 semester | graduate | Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

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**

(No information on SWS (weekly contact hours) and course language available)

S

**Method of assessment**

(No information on SWS (weekly contact hours) and course language available)

At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

--
## Seminar in Complex Analysis

### Module title
Seminar in Complex Analysis

### Abbreviation
10-M=SFTH-102-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
Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

### 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 (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes
Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.
Language of assessment: German, 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 Catalogue for the Subject
Mathematics
Master's with 1 major, 120 ECTS credits

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<td>Seminar Financial and Insurance Maths</td>
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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 (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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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<td>Seminar in Geometry and Topology</td>
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</table>

**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 (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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 Seminar (Master)
Abbreviation: 10-M=SGPC-102-m01

Module coordinator: Dean of Studies Mathematik (Mathematics)
Module offered by: Institute of Mathematics

ECTS: 5
Method of grading: numerical grade
Duration: 1 semester
Module level: graduate
Other prerequisites: Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

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
S (no information on SWS (weekly contact hours) and course language available)

Method of assessment
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes
Language of assessment: English, German if agreed upon with the examiner

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
Interdisciplinary Seminar

### Abbreviation
10-M=SIDZ-102-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
Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

### 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
S (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes

Language of assessment: German, 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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<th>Duration</th>
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</table>

**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 (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes.

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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
Seminar in Numerical Mathematics and Applied Analysis

### Abbreviation
10-M=SNMA-102-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
Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.

### 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
(S (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes

### Language of assessment
German, English

### Allocation of places
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### Additional information
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### Referred to in LPO
(examination regulations for teaching-degree programmes)
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<table>
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<td>Seminar in Optimization</td>
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</table>

### 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 (no information on SWS (weekly contact hours) and course language available)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

### Allocation of places

--

### Additional information

--

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

--

### Other prerequisites

Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.
### Module Catalogue for the Subject Mathematics

**Master's with 1 major, 120 ECTS credits**

<table>
<thead>
<tr>
<th>Module title</th>
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<tbody>
<tr>
<td>Seminar in Statistics</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 (no information on SWS (weekly contact hours) and course language available)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, 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)

--
Learning by Teaching
(max. 10 ECTS credits)

Students may choose whether or not to take modules in this area.
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<td>10-M=ELT1-102-m01</td>
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### Contents
Supervising a tutorial or study group in the Bachelor’s programme under guidance of the respective lecturer.

### Intended learning outcomes
The student gains his/her first experience in teaching university mathematics. He/She knows basic didactical methods and can apply them in practical situations.

### Courses (type, number of weekly contact hours, language — if other than German)
Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
practical examination (approx. 90 minutes)
Language of assessment: German, 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>Dean of Studies Mathematik (Mathematics)</td>
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<tbody>
<tr>
<td>1 semester</td>
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</table>

### Contents
Supervising a tutorial or study group in the Bachelor’s programme under guidance of the respective lecturer.

### Intended learning outcomes
The student gains his/her first experience in teaching university mathematics. He/She knows basic didactical methods and can apply them in practical situations.

### Courses
(No type, number of weekly contact hours, language available)

### Method of assessment
practical examination (approx. 90 minutes)
Language of assessment: German, 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)
Optional Application-oriented Subject and/or Application-oriented Work Placement
(max. 30 ECTS credits)

Students may choose whether or not to take modules in this area. Students may choose to complete modules from the specified application-oriented subjects and/or an application-oriented work placement worth a total of no more than 30 ECTS credits.
Application-oriented Subject Biology
(10 ECTS credits)
<table>
<thead>
<tr>
<th><strong>Module title</strong></th>
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<tbody>
<tr>
<td>Bioinformatics (Lecture and Seminar)</td>
<td>07-MS2BI-102-m01</td>
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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, lncRNAs).

**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**
S + V (no information on SWS (weekly contact hours) and course language available)

**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 (approx. 30 to 60 minutes)

**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)

S + P (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Students will be informed about the 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 (approx. 10 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 (approx. 30 to 60 minutes) or e) presentation (20 to 45 minutes)

**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 Catalogue for the Subject
Mathematics
Master's with 1 major, 120 ECTS credits

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<tr>
<td>1 semester</td>
<td>graduate</td>
<td>Admission prerequisite to assessment: regular attendance of lab course and successful completion of the respective exercises as specified at the beginning of the course.</td>
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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
S + P (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
Students will be informed about the 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 (approx. 10 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 (approx. 30 to 60 minutes) or e) presentation (20 to 45 minutes)

### Allocation of places
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### Additional information
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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, lncRNAs).

### 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

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<thead>
<tr>
<th>(type, number of weekly contact hours, language — if other than German)</th>
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### Method of assessment

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### Allocation of places

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### Additional information

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**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**

S + V (no information on SWS (weekly contact hours) and course language available)

**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 (approx. 30 to 60 minutes)

**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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**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 + S (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
Students will be informed about the 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 (approx. 10 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 (approx. 30 to 60 minutes) or e) presentation (20 to 45 minutes)

**Allocation of places**

**Additional information**

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

---
## Module title
System Biology (Practical Course and Seminar 2)

## Abbreviation
07-MS3SYF2-102-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)

### Duration
1 semester

### Module level
graduate

### Other prerequisites
Admission prerequisite to assessment: regular attendance of lab course and successful completion of the respective exercises as specified at the beginning of the course.

### 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 modeling). 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
P + S (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
Students will be informed about the 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 (approx. 10 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 (approx. 30 to 60 minutes) or e) presentation (20 to 45 minutes)

### 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
---|---
Systems Biology B | 07-MS-B-121-m01

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

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

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 (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
Students will be informed about the method, length and scope of the assessment prior to the course. 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)

Allocation of places
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Additional information
--

Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Application-oriented Subject Chemistry

(ECTS credits)
Module title | Abbreviation
---|---
Computational Chemistry | 08-TCM2-102-m01

Module coordinator | Module offered by
lecturer of lecture "Computational Chemistry" | Institute of Physical and Theoretical Chemistry

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<td>Admission prerequisite to assessment: successful completion of exercises in the respective classes as specified at the beginning of the course (usually 70% of exercises to be successfully completed) as well as regular attendance of exercises (usually a maximum of 2 incidents of unexcused absence).</td>
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</table>

Contents

The module introduces students to computational chemistry.

Intended learning outcomes

Students are able to explain the theoretical principles of computational chemistry and to apply methods in computational chemistry.

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

S + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (90 minutes)
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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</table>

**Contents**

The module introduces students to theoretical chemistry.

**Intended learning outcomes**

Students are able to describe the mathematical and physical principles underlying the quantum chemical and quantum dynamical approaches of theoretical chemistry.

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

S + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (90 minutes)

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>lecturer of lecture &quot;Programmieren in Theoretischer Chemie&quot;</td>
<td>Institute of Physical and Theoretical Chemistry</td>
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**Contents**

This module provides an introduction to the fundamentals of programming in theoretical chemistry and discusses its application areas.

**Intended learning outcomes**

Students are able to explain and use one of the programming languages typically used in theoretical chemistry as well as to name its application areas.

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

S + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

completion and discussion of approx. 5 programming exercises as well as talk (approx. 45 minutes)
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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**Module coordinator**

head of the research group offering the module

**Module offered by**

Institute of Physical and Theoretical Chemistry

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**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

--

**Contents**

This module gives students the opportunity to get involved in the work of one of the research groups based at the Institute of Theoretical Chemistry and learn some of the methods typically used in the discipline.

**Intended learning outcomes**

Students have learned some of the methods typically used in theoretical chemistry. They are able to explain issues that are relevant to the fields covered.

**Courses**

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

This module has 3 components; information on courses listed separately for each component.

- 08-TCAP-1-102: P (no information on language and number of weekly contact hours available)
- 08-TCAP-2-102: P (no information on language and number of weekly contact hours available)
- 08-TCAP-3-102: P (no information on language and number of weekly contact hours available)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

This module has the following 3 assessment components. To pass the module as a whole students must pass two out of these three assessment components.

**Assessment component to module component 08-TCAP-1-102: Theoretische Chemie Arbeitsgruppenpraktikum Wellenpaketdynamik**

- 5 ECTS credits, method of grading: (not) successfully completed
- presentation (approx. 30 minutes)
- Language of assessment: German or English

**Assessment component to module component 08-TCAP-2-102: Theoretische Chemie Arbeitsgruppenpraktikum Wellenfunktionsmethoden**

- 5 ECTS credits, method of grading: (not) successfully completed
- presentation (approx. 30 minutes)
- Language of assessment: German or English

**Assessment component to module component 08-TCAP-3-102: Theoretische Chemie Arbeitsgruppenpraktikum Dichtefunktionaltheorie**

- 5 ECTS credits, method of grading: (not) successfully completed
- presentation (approx. 30 minutes)
- Language of assessment: German or English

**Allocation of places**

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**Additional information**

Additional information on module duration: 4 weeks..

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

--
Module title | Abbreviation
--- | ---
Advanced Physical Chemistry | 08-PCM1-102-m01

Module coordinator
Lecturer of seminar "Laserspektroskopie" (Laser Spectros-
scopy)

Module offered by
Institute of Physical and Theoretical Chemistry

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

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

Contents
This module introduces students to the fundamental principles of laser spectroscopy. It discusses absorption
and emission spectroscopy. In addition, the module gives students the opportunity to use modern experimen-
tal methods in physical chemistry in the laboratory. After a safety briefing, the students autonomously conduct
experiments in the laboratory. Students will be expected to take tests and write lab reports to demonstrate their
knowledge.

Intended learning outcomes
Students are able to explain the components and operating principles of lasers as well as the optical principles
of laser technology. They are able to describe the principles of absorption and emission spectroscopy. Students
have developed a high level of proficiency in modern experimental methods in physical chemistry. They are able
to analyse the resulting measurements and write a lab report.

Courses (type, number of weekly contact hours, language — if other than German)
This module comprises 2 module components. Information on courses will be listed separately for each module
component.

- 08-PCM1-1-102: S + Ü (no information on SWS (weekly contact hours) and course language available)
- 08-PCM1-2-102: P (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
Assessment in this module comprises the assessments in the individual module components as specified be-
low. Unless stated otherwise, successful completion of the module will require successful completion of all indi-
vidual assessments.

Assessment in module component 08-PCM1-1-102: Laser Spectroscopy
- 5 ECTS, Method of grading: numerical grade
- written examination (90 minutes) or oral examination (20 minutes)
- Language of assessment: German or English

Assessment in module component 08-PCM1-2-102: Advanced Physical Chemistry (Lab)
- 5 ECTS, Method of grading: (not) successfully completed
- Vortestate (pre-experiment exams) and Nachtestate (post-experiment exams) (approx. 15 minutes), log
  (approx. 15 pages)
- Language of assessment: German or English
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<td>Chemical Dynamics</td>
<td>08-PCM2-102-m01</td>
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<tr>
<td>lecturer of seminar &quot;Chemische Dynamik&quot;</td>
<td>Institute of Physical and Theoretical Chemistry</td>
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<tr>
<td>1 semester</td>
<td>graduate</td>
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</table>

**Contents**

This module gives students the opportunity to explore advanced topics in chemical kinetics and reaction dynamics in more detail. It discusses methods and models for investigating and describing chemical reactions.

**Intended learning outcomes**

Students are able to discuss advanced topics in chemical kinetics and reaction dynamics. They can describe methods and models for the investigation of chemical reactions.

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

S + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (90 minutes) or oral examination of one candidate each (20 minutes) or talk (30 minutes) 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>Nanoscale Materials</td>
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<tbody>
<tr>
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<td>Institute of Physical and Theoretical Chemistry</td>
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<td>1 semester</td>
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**Contents**

This module discusses advanced topics in nanoscale materials. It focuses on the structure, properties, fabrication, modern characterisation methods and application areas of nanoscale materials.

**Intended learning outcomes**

Students are able to characterise nanoscale materials. They are able to name analytical methods and application areas of nanoscale materials.

**Courses**

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

S + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (90 minutes) or oral examination of one candidate each (20 minutes) or talk (30 minutes)

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

**Ultrafast spectroscopy and quantum-control**

### Abbreviation

08-PCM4-102-m01

### Module coordinator

lecturer of the seminar "Ultrakurzzeitspektroskopie und Quantenkontrolle"

### 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

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### Contents

This module discusses advanced topics in ultrafast spectroscopy and quantum control. It focuses on ultrashort laser pulses, time-resolved laser spectroscopy and coherent control.

### Intended learning outcomes

Students are able to describe the generation of ultrashort laser pulses and to characterise them. They can explain the theory of time-resolved laser spectroscopy and name experimental methods. They can describe the principles and applications of quantum control.

### Courses

S + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

written examination (90 minutes) or oral examination of one candidate each (20 minutes) or talk (30 minutes)

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

**Physical chemistry of supramolecular assemblies**

**Abbreviation**

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<tr>
<td>Physical chemistry of supramolecular assemblies</td>
<td>08-PCM5-102-m01</td>
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### Module coordinator

Lecturer of the seminar "Physikalische Chemie Supramolekularer Strukturen"

### Module offered by

Institute of Physical and Theoretical Chemistry

### ECTS

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</table>

### Contents

This module examines the basic interactions between molecules. It discusses the formation and physical-chemical properties of aggregates as well as key applications of supramolecular chemistry.

### Intended learning outcomes

Students are able to explain the basic interactions between molecules demonstrating a high degree of expertise in the field. They can describe the formation and physical-chemical properties of aggregates. They can name modern applications of supramolecular chemistry.

### Courses

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### Method of assessment

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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>Physical Chemistry (Advanced Lab)</td>
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**Module coordinator**

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**Duration**

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**Contents**

This module gives students the opportunity to get involved in the work of one of the research groups based at the Institute of Physical Chemistry and learn some advanced synthesis and analytical methods.

**Intended learning outcomes**

Students have become proficient in the research methods typically used by the relevant physical chemistry research group. They are able to analyse their findings and thus help answer topical questions in physical chemistry.

**Courses**

P (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

presentation (20 minutes)

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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Application-oriented Subject Computer Science
(ECTS credits)
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<td>Admission prerequisite to assessment: exercises (type and scope to be announced by the lecturer at the beginning of the course).</td>
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</table>

**Contents**

Relational algebra and complex SQL statements; database planning and normal forms; transaction management.

**Intended learning outcomes**

The students possess knowledge about database modelling and queries in SQL as well as transactions.

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

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

**Allocation of places**

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**Additional information**

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

§ 49 (1) 1. b) Datenbanksysteme und Softwaretechnologie

§ 69 (1) 1. b) Datenbanksysteme und Softwaretechnologie
## Module: Data Mining

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<td>Data Mining</td>
<td>10-I-DM-102-m01</td>
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### 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 undergraduate

### Other prerequisites Admission prerequisite to assessment: exercises (type and scope to be announced by the lecturer at the beginning of the course).

### 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
V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

### 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>Algorithmic Graph Theory</td>
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<td>Institute of Computer Science</td>
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<td>undergraduate</td>
<td>Where applicable, prerequisites as specified by the lecturer at the beginning of the course (e.g. completion of exercises).</td>
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</table>

**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**

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: English, German if agreed upon with the examiner

**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 Complexity

### Abbreviation

10-I-KT-102-m01

### Module coordinator

Dean of Studies Informatik (Computer Science)

### Module offered by

Institute of Computer Science

### ECTS

5

### Method of grading

Numerical grade --

### Duration

1 semester

### Module level

Undergraduate

### Other prerequisites

Admission prerequisite to assessment: exercises (type and scope to be announced by the lecturer at the beginning of the course).

### 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

(V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

Written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

### 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>
<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 + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

**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 Geometry

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## Module coordinator

holder of the Chair of Computer Science I

## 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

Where applicable, prerequisites as specified by the lecturer at the beginning of the course (e.g. completion of exercises).

## 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

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## Method of assessment

- written examination (approx. 50 to 60 minutes); if announced by the lecturer four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

## 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>
<td>Where applicable, prerequisites as specified by the lecturer at the beginning of the course (e.g. completion of exercises).</td>
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</table>

**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**

\(V + Ü\) (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)
## Approximation Algorithms

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<td>10-I=APA-102-m01</td>
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### 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

- V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

- written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)
- Language of assessment: German, English if agreed upon with the examiner

### 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
---|---
Automata Theory | 10-I=AUT-102-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 | graduate | Admission prerequisite to assessment: exercises (type and scope to be announced by the lecturer at the beginning of the course).

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 + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)
Language of assessment: German, English if agreed upon with the examiner

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: Computability Theory  
Abbreviation: 10-I=BER-102-m01

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

ECTS: 5  
Method of grading: numerical grade
Duration: 1 semester  
Module level: graduate

Other prerequisites: Admission prerequisite to assessment: exercises (type and scope to be announced by the lecturer at the beginning of the course).

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:
V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment:
written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)
Language of assessment: German, English if agreed upon with the examiner

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>

**Contents**

Data warehouses and data mining; XML databases; web databases; introduction to Datalog.

**Intended learning outcomes**

The students have advanced knowledge about relational databases, XML and data mining.

**Courses**

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

**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 Catalogue for the Subject Mathematics

## Master's with 1 major, 120 ECTS credits

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<td>E-Learning</td>
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</table>

## 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

V + Ü (no information on SWS (weekly contact hours) and course language available)

## Method of assessment

Written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes).

Language of assessment: German, English if agreed upon with the examiner.

## 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
Cryptography and Data Security

### Abbreviation
10-I=KD-102-m01

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

### Module offered by
Institute of Computer Science

### ECTS
5

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

### Duration
1 semester

### Module level
graduate

### Other prerequisites
Where applicable, prerequisites as specified by the lecturer at the beginning of the course (e.g. completion of exercises).

### 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
V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)
Language of assessment: German, English if agreed upon with the examiner

### Allocation of places
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</table>

**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**

(V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

Written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

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**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**

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes) 

Language of assessment: German, English if agreed upon with the examiner

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**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 + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

**Allocation of places**

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**Additional information**

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**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 + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

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### Contents

Overview of automation systems, fundamental principles of control technology, Laplace transformation, transfer function, plant, controller types, basic feedback loop, fundamental principles of control engineering, automata, structure of Petri nets, Petri nets for automatisation, machine-related structure of processing computation machines, communication between process computers and periphery devices, software for automation systems, process synchronisation, process communication, real-time operating systems, real-time planning.

### Intended learning outcomes

The students master the fundamentals of automation and control.

### Courses

V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

written examination (approx. 80 to 90 minutes). If announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups. A 80 to 90 minute written examination is equivalent to a 20 minute (approx.) oral examination of one candidate each, a 30 minute (approx.) oral examination in groups of 2 and a 40 minute (approx.) oral examination in groups of 3.

Language of assessment: German, English if agreed upon with the examiner

### Allocation of places

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**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**

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

Written examination (approx. 80 to 90 minutes). If announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups. A 80 to 90 minute written examination is equivalent to a 20 minute (approx.) oral examination of one candidate each, a 30 minute (approx.) oral examination in groups of 2 and a 40 minute (approx.) oral examination in groups of 3.

Language of assessment: German, English if agreed upon with the examiner.

**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>Deductive Databases</td>
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</tbody>
</table>

**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**

(V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

written examination (approx. 80 to 90 minutes). If announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups. A 80 to 90 minute written examination is equivalent to a 20 minute (approx.) oral examination of one candidate each, a 30 minute (approx.) oral examination in groups of 2 and a 40 minute (approx.) oral examination in groups of 3.

Language of assessment: German, English if agreed upon with the examiner

**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
---|---
Artificial Intelligence | 10-I=KI-102-m01

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

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

Duration | Module level | Other prerequisites
1 semester | graduate | Where applicable, prerequisites as specified by the lecturer at the beginning of the course (e.g. completion of exercises).

Contents
Intelligent agents, uninformed and heuristic search, constraint problem solving, search with partial information, propositional and predicate logic and inference, knowledge representation, 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.

Intended learning outcomes
The students possess theoretical and practical knowledge about artificial intelligence and are able to assess possibilities for its application.

Courses (type, number of weekly contact hours, language — if other than German)
V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
written examination (approx. 80 to 90 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)
Language of assessment: German, English if agreed upon with the examiner

Allocation of places
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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 + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

**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 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 + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 80 to 90 minutes). If announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups. A 80 to 90 minute written examination is equivalent to a 20 minute (approx.) oral examination of one candidate each, a 30 minute (approx.) oral examination in groups of 2 and a 40 minute (approx.) oral examination in groups of 3.

Language of assessment: German, English if agreed upon with the examiner

**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
---|---
Simulation Techniques for Performance Evaluation | 10-I=ST-102-m01

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

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

Duration | Module level | Other prerequisites
1 semester | graduate | Where applicable, prerequisites as specified by the lecturer at the beginning of the course (e.g., completion of exercises).

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 + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
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Language of assessment: German, English if agreed upon with the examiner

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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Application-oriented Subject Aerospace Computer Science
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</table>

**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 + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 50 to 60 minutes); if announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups (one candidate each: 15 minutes, groups of 2: 20 minutes, groups of 3: 25 minutes)

Language of assessment: German, English if agreed upon with the examiner

**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 (1) 1. c) Informatik Technische Informatik
### Module title

Automation and Control Technology

### Abbreviation

10-I-AR-102-m01

### Module coordinator

holder of the Chair of Computer Science VII

### Module offered by

Institute of Computer Science

### ECTS

8

### Method of grading

Only after succ. compl. of module(s)

### numerical grade

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### Duration

1 semester

### Module level

undergraduate

### Other prerequisites

Admission prerequisite to assessment: exercises (type and scope to be announced by the lecturer at the beginning of the course).

### Contents

Overview of automation systems, fundamental principles of control technology, Laplace transformation, transfer function, plant, controller types, basic feedback loop, fundamental principles of control engineering, automata, structure of Petri nets, Petri nets for automisation, machine-related structure of processing computation machines, communication between process computers and periphery devices, software for automation systems, process synchronisation, process communication, real-time operating systems, real-time planning.

### Intended learning outcomes

The students master the fundamentals of automation and control.

### Courses

V + Ü (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

written examination (approx. 80 to 90 minutes). If announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups. A 80 to 90 minute written examination is equivalent to a 20 minute (approx.) oral examination of one candidate each, a 30 minute (approx.) oral examination in groups of 2 and a 40 minute (approx.) oral examination in groups of 3.

Language of assessment: German, English if agreed upon with the examiner

### 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

Computer Networks and Communication Systems

### Abbreviation

10-I-RK-102-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)

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### Duration

1 semester

### Module level

undergraduate

### Other prerequisites

Admission prerequisite to assessment: exercises (type and scope to be announced by the lecturer at the beginning of the course).

## 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

V + Ü (no information on SWS (weekly contact hours) and course language available)

## Method of assessment

written examination (approx. 80 to 90 minutes). If announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups. A 80 to 90 minute written examination is equivalent to a 20 minute (approx.) oral examination of one candidate each, a 30 minute (approx.) oral examination in groups of 2 and a 40 minute (approx.) oral examination in groups of 3.

Language of assessment: German, English if agreed upon with the examiner

## Allocation of places

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**Module coordinator**

holder of the Chair of Computer Science VII

**Module offered by**

Institute of Computer Science

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**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

Where applicable, prerequisites as specified by the lecturer at the beginning of the course (e.g. completion of exercises).

**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**

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

written examination (approx. 80 to 90 minutes). If announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups. A 80 to 90 minute written examination is equivalent to a 20 minute (approx.) oral examination of one candidate each, a 30 minute (approx.) oral examination in groups of 2 and a 40 minute (approx.) oral examination in groups of 3. Language of assessment: German, English if agreed upon with the examiner

**Allocation of places**

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</table>

**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**

(V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

written examination (approx. 80 to 90 minutes). If announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups. A 80 to 90 minute written examination is equivalent to a 20 minute (approx.) oral examination of one candidate each, a 30 minute (approx.) oral examination in groups of 2 and a 40 minute (approx.) oral examination in groups of 3.

Language of assessment: German, English if agreed upon with the examiner

**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**

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

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 80 to 90 minutes). If announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups. A 80 to 90 minute written examination is equivalent to a 20 minute (approx.) oral examination of one candidate each, a 30 minute (approx.) oral examination in groups of 2 and a 40 minute (approx.) oral examination in groups of 3.

Language of assessment: German, English if agreed upon with the examiner

**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

(V + Ü) (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

Written examination (approx. 80 to 90 minutes). If announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups. A 80 to 90 minute written examination is equivalent to a 20 minute (approx.) oral examination of one candidate each, a 30 minute (approx.) oral examination in groups of 2 and a 40 minute (approx.) oral examination in groups of 3.

Language of assessment: German, English if agreed upon with the examiner

### 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: Spacecraft Systems Design
Abbreviation: 10-I=SSD-102-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 --
Duration: 1 semester
Module level: graduate
Other prerequisites: Where applicable, prerequisites as specified by the lecturer at the beginning of the course (e.g. completion of exercises).

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:
V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment:
written examination (approx. 80 to 90 minutes). If announced by the lecturer by four weeks prior to the examination date, the written examination can be replaced by an oral examination of one candidate each or an oral examination in groups. A 80 to 90 minute written examination is equivalent to a 20 minute (approx.) oral examination of one candidate each, a 30 minute (approx.) oral examination in groups of 2 and a 40 minute (approx.) oral examination in groups of 3.
Language of assessment: German, English if agreed upon with the examiner

Allocation of places: --

Additional information: --

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

--
Application-oriented Subject Physics

(ECTS credits)
Module title | Abbreviation
--- | ---
Semiconductor Physics and Devices | 11-SPD-102-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 | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
Principles of Semiconductor Physics. Introduction to key theories on semiconductors. Components from the areas of electronics and photonics.

Intended learning outcomes
The students are familiar with the properties of semiconductors, they have gained an overview of the electronic and phonon band structures of important semiconductors and the resulting electronic, optical and thermal properties. They know the principles of charge transport and are able to apply Poisson, Boltzmann and continuity equations to the solution of questions. They have gained insights into the methods of semiconductor production and are familiar with the methods of planar technology and current developments in this sector, they have a basic understanding of component production. They understand the structure and function of the main components of electronics (diodes, transistor, FET, thyristor, diac, triac), microwave applications (tunnel, impatt, barritt and Gunn diode) and optoelectronics (photo diode, solar cell, light-emitting diode, semiconductor injection laser). They know the realisation possibilities of low-dimensional charge carrier systems on the basis of semiconductors and their technological importance. They are familiar with current developments in the field of components.

Courses (type, number of weekly contact hours, language — if other than German)
V + R (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
written examination (approx. 90 minutes) or oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or presentation/seminar presentation (approx. 30 minutes)
Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English

Allocation of places
--

Additional information
--
Referred to in LPO I (examination regulations for teaching-degrees programmes)

--
### Module title

**Solid State Physics 2**

<table>
<thead>
<tr>
<th><strong>Abbreviation</strong></th>
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</thead>
<tbody>
<tr>
<td>11-FK2-092-m01</td>
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### Module coordinator

Managing Director of the Institute of Applied Physics

### Module offered by

Faculty of Physics and Astronomy

### ECTS

<table>
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<tr>
<th><strong>Method of grading</strong></th>
<th><strong>Only after succ. compl. of module(s)</strong></th>
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### Duration

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<th><strong>Module level</strong></th>
<th><strong>Other prerequisites</strong></th>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.</td>
</tr>
</tbody>
</table>

### Contents


### Intended learning outcomes

The students have specific and advanced knowledge in the field of Solid-State Physics. They are theoretically able to specialise in a sub-discipline of Solid-State Physics.

### Courses

R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

<table>
<thead>
<tr>
<th><strong>Type</strong></th>
<th><strong>Scope</strong></th>
<th><strong>Language</strong></th>
<th><strong>Examination offered</strong></th>
<th><strong>Module is creditable for bonus</strong></th>
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<tr>
<td>a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)</td>
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<tr>
<td>Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.</td>
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<tr>
<td>Language of assessment: German, English</td>
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</table>

### 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
--- | ---
Solid State Spectroscopy | 11-FKS-092-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 | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

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
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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: Semiconductor Lasers - Principles and Current Research
Abbreviation: 11-HLF-092-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:
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents:
This lecture discusses the principles of laser physics, based on the example of semiconductor lasers, and current developments regarding components. The principles of lasers are described on the basis of a general laser model, which will then be extended to special aspects of semiconductor lasers. Basic concepts such as threshold condition, characteristic curve and laser efficiency are derived from coupled rate equations for charge carriers and photons. Other topics of the lecture are optical processes in semiconductors, layer and ridge waveguides, laser resonators, mode selection, dynamic properties as well as technology for the generation of semiconductor lasers. The lecture closes with current topics of laser research such as quantum dot lasers, quantum cascade lasers, terahertz lasers or high-performance lasers.

Intended learning outcomes:
The students have advanced knowledge of the principles of semiconductor-laser physics. They can apply their knowledge to modern questions and know the applications in the current development of components.

Courses:
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment:
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocation of places:
--

Additional information:
--

Referred to in LPO 1 (examination regulations for teaching-degree programmes): --
Module title | Abbreviation
---|---
Semiconductor Physics | 11-HLP-092-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 | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents

Intended learning outcomes
The students have specific and advanced knowledge in the field of Semiconductor Physics. They know the physical principles of semiconductors and have gained an overview of the important characteristics of semiconductor materials.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)
Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English

Allocation of places
--

Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Module title | Abbreviation
--- | ---
Semiconductor Nanostructures | 11-HNS-092-m01

Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

<table>
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<tr>
<th>ECTS</th>
<th>Method of grading</th>
<th>Other prerequisites</th>
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| 6 | numerical grade | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

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

R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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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<table>
<thead>
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<th>Module title</th>
<th>Abbreviation</th>
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<tr>
<td>Experimental Particle Physics</td>
<td>11-TPE-092-m01</td>
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<td>Managing Director of the Institute of Applied Physics</td>
<td>Faculty of Physics and Astronomy</td>
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<thead>
<tr>
<th>Duration</th>
<th>Module level</th>
<th>ECTS</th>
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<tbody>
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<td>graduate</td>
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Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

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

R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment

<table>
<thead>
<tr>
<th>Type</th>
<th>Scope</th>
<th>Language</th>
<th>Examination offered</th>
<th>If not every semester, information on whether module is creditable for bonus</th>
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<tr>
<td>a)</td>
<td>written examination (approx. 90 minutes)</td>
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<tr>
<td>b)</td>
<td>oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes)</td>
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<tr>
<td>c)</td>
<td>project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks)</td>
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<tr>
<td>d)</td>
<td>presentation/seminar presentation (approx. 30 minutes)</td>
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Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocation of places

—

Additional information

—

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

—
Module title | Abbreviation
---|---
Astrophysics | 11-A4-072-m01

Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by
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 | undergraduate | Admission prerequisite to assessment: successful completion of approx. 50% of exercises. Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
History of astronomy, coordinates and time measurement, the solar system, size scales in outer space, telescopes and detectors, stellar structure, stellar atmospheres, stellar evolution, final stages of stellar evolution, interstellar medium, structure of the Milky Way, local universe, expanding space-time, galaxies, active galactic nuclei, large-scale structure of the universe, Friedmann World Models, thermodynamics of the early universe, primordial nucleosynthesis, cosmic microwave background radiation, structure formation, inflation

Intended learning outcomes
The students are familiar with the modern world view of Astrophysics. They know methods and tools for astrophysical observations and evaluations. They are able to use these methods to plan and analyse own observations. They know the structure of the universe, e.g. of stars and galaxies and understand the process of their development.

Courses (type, number of weekly contact hours, language — if other than German)
V + S (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
written examination (approx. 120 minutes)

Allocation of places
Only as part of pool of general key skills (ASQ): 15 places. Places will be allocated by lot.

Additional information
--

Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Module title
Atmosphere and Space Physics

### Abbreviation
11-AWP-092-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
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

### Contents

### Intended learning outcomes
The students have knowledge of the physics of planetary atmospheres, especially of the atmosphere of the Earth and near-Earth space. They are able to apply the acquired knowledge to the solution of problems of interplanetary space missions.

### Courses
R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German or English

### Allocation of places
--

### Additional information
--

### 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>Particle Physics (Standard Model)</td>
<td>11-TPS-092-m01</td>
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<tr>
<td>Managing Directors of the Institute of Applied Physics and the Institute of Theoretical Physics and Astrophysics</td>
<td>Faculty of Physics and Astronomy</td>
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<tr>
<th>Duration</th>
<th>Module level</th>
<th>Other prerequisites</th>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</tr>
</tbody>
</table>

**Contents**

Introduction to the theory of electroweak interaction and spontaneous symmetry breaking. Experiments on the standard model and determination of model parameters.

**Intended learning outcomes**

The students know the theoretical fundamental laws of the standard model of Particle Physics and the key experiments that have established and confirmed the standard model. They are able to interpret experimental or theoretical results in the framework of the standard model and know its validity and limits.

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

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes) 

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

**Allocation of places**

--

**Additional information**

--

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

--
## Module title
Statistics, Data Analysis and Computer Physics

## Abbreviation
11-SDC-092-m01

## Module coordinator
Managing Director of the Institute of Applied Physics

## Module offered by
Faculty of Physics and Astronomy

## ECTS
4

## Method of grading
--

## Duration
1 semester

## Module level
graduate

## Other prerequisites
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

## Contents
Statistics, data analysis and computer physics.

## Intended learning outcomes
The students have specific and advanced knowledge in the field of statistics, data analysis and Computational Physics.

## Courses
R + V (no information on SWS (weekly contact hours) and course language available)

## Method of assessment
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

## Allocation of places
--

## Additional information
--

## Referred to in LPO I
(examination regulations for teaching-degree programmes)
Module title | Abbreviation
--- | ---
Quantum Mechanics II | 11-QM2-092-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)
--- | --- | ---
8 | numerical grade | --

Duration | Module level | Other prerequisites
--- | --- | ---
1 semester | undergraduate | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
"Quantum mechanics II" constitutes the central theoretical course of the international Master’s program in Physics. It builds upon basics which are acquired in the lecture "Quantum mechanics I" of the Bachelor’s degree. While the specific emphasis can be adjusted individually, the core topics that are supposed to be covered should include:
1. Second quantisation: Fermions and bosons
2. Band structures of particles in a crystal
3. Angular momentum, symmetry operators, Lie Algebras
4. Scattering theory: Potential scattering, partial wave expansion
5. Relativistic quantum mechanics: Klein-Gordon equation, Dirac equation, Lorentz group, fine structure splitting of atomic spectra
6. Quantum entanglement
7. Canonical formalism

Intended learning outcomes
The students acquire in-depth knowledge of advanced quantum mechanics and have a thorough understanding of the mathematical and theoretical concepts of the listed topics. They are able to describe or model problems of modern theoretical Quantum Physics mathematically, to solve problems analytically, to use approximation methods and to interpret the results physically. The course is pivotal to subsequent theory courses in Astrophysics, High-Energy Physics and Condensed Matter/Solid-State Physics. The course is mandatory for all Master’s students.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)
Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.
Language of assessment: German, English
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<th>Allocation of places</th>
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<tr>
<td>Additional information</td>
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</tr>
<tr>
<td>Referred to in LPO I</td>
<td>(examination regulations for teaching-degree programmes)</td>
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<tr>
<td>Module title</td>
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<tr>
<td>Theoretical Solid State Physics</td>
<td>11-TFK-092-m01</td>
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<td>Managing Director of the Institute of Theoretical Physics and Astrophysics</td>
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### Contents

### Intended learning outcomes
The students have basic knowledge of the theoretical description of solid-state phenomena. They know the corresponding mathematical or theoretical methods and are able to apply them to basic problems of solid-state theory and to understand the connections to experimental results. The individual students have elaborated on an advanced topic of solid-state theory and have discussed this topic in a seminar presentation.

### Courses
R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
(a) written examination (approx. 90 minutes) or (b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or (c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or (d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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 Catalogue for the Subject Mathematics

#### Master's with 1 major, 120 ECTS credits

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<thead>
<tr>
<th>Module title</th>
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<tr>
<td>Theory of Superconduction</td>
<td>11-TSL-092-m01</td>
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### Contents


### Intended learning outcomes

The students have basic knowledge of the theoretical models for the description of superconductivity. They know the properties and application areas of these models and are able to apply calculation methods to simple problems.

### Courses

R + V (no information on SWS (weekly contact hours) and course language available)

### Method of assessment

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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
---|---
Cosmology | 11-AKM-092-m01

Module coordinator | Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy

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Duration | Module level | Other prerequisites
1 semester | graduate | Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents
Expanding space-time, Friedmannian cosmology, basics of general relativity, the early universe, inflation, dark matter, primordial nucleosynthesis, cosmic microwave background, structure formation, supercluster, 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 work on scientific questions.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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: Plasma-Astrophysics

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<th>Abbreviation</th>
<th>11-APL-092-m01</th>
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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

#### ECTS
6

#### Method of grading
Numerical grade

#### Other prerequisites
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

#### Contents

#### Intended learning outcomes
The students have basic knowledge of Plasma Astrophysics. They have mastered the theoretical description of motion and acceleration of charged particles in space, they know corresponding measuring methods and can compare and evaluate theory and experiments.

#### Courses
R + V (no information on SWS (weekly contact hours) and course language available)

#### Method of assessment
- a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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)
--
Module title: Introduction to Space Physics
Abbreviation: 11-ASP-092-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:
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

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 have basic knowledge of Space Physics, in particular of the characterisation of the dynamics of charged particles in space and in the heliosphere. They know relevant parameters, theoretical concepts and measuring methods.

Courses
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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-092-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: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Contents


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)

R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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 Catalogue for the Subject Mathematics

## Master's with 1 major, 120 ECTS credits

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<tr>
<th>Module title</th>
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<tr>
<td>Group Theory</td>
<td>11-GRT-092-m01</td>
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## Contents


## Intended learning outcomes

The students know the basics of group theory, especially of Lie groups. They are able to identify problems of group theory and to solve them by using the acquired methods. They are able to apply group theory to the formulation and processing of physical problems.

## Courses

- R + V (no information on SWS (weekly contact hours) and course language available)

## Method of assessment

- a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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)

--
### Computational Astrophysics

**Module title**
Computational Astrophysics

**Abbreviation**
11-NMA-111-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**
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

**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 + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**
(a) written examination (approx. 120 minutes) or (b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or (c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or (d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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
---|---
Supersymmetry I and II | 11-SUS-092-m01

Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by
Faculty of Physics and Astronomy

<table>
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Duration | Module level | Other prerequisites
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Contents

Intended learning outcomes
The students have knowledge of the mathematical and physical principles of supersymmetry and supersymmetric models. They understand the theory's formalism and recognise its connections to other models as well as its importance for phenomenology of elementary particles.

Courses
V + R (no information on SWS (weekly contact hours) and course language available)

Method of assessment
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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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Renormalization Theory | 11-RNT-092-m01

Module coordinator | Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy

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Duration | Module level | Other prerequisites
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Contents

Intended learning outcomes
The students have gained an overview of renormalisation group methods for non-linear partial differential equations. They know important examples and corresponding solving methods and are able to apply them to specific tasks.

Courses (type, number of weekly contact hours, language — if other than German)
R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
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Language of assessment: German, English

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<td>Relativistic Quantumfield Theory</td>
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**Contents**


**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**

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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 Plasmaphysics
Abbreviation: 11-EPP-092-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: Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

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 know the principles of Plasma Physics, especially the description of transport phenomena in plasma. They are able to solve basic problems of Plasma Physics and to apply this knowledge to Astrophysics.

Courses:
V + R (no information on SWS (weekly contact hours) and course language available)

Method of assessment:
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

Allocation of places:

Additional information:

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>
</tr>
</thead>
<tbody>
<tr>
<td>Theory of Relativity</td>
<td>11-RTT-092-m01</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managing Director of the Institute of Theoretical Physics and Astrophysics</td>
<td>Faculty of Physics and Astronomy</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>ECTS</th>
<th>Method of grading</th>
<th>Only after succ. compl. of module(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>numerical grade</td>
<td>--</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Duration</th>
<th>Module level</th>
<th>Other prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
<td>Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.</td>
</tr>
</tbody>
</table>

**Contents**

- Mathematical foundations of the theory of relativity; differential forms;
- Brief summary of special relativity; elements of differential geometry;
- Electrodynamics as an example of a relativistic gauge theory;
- Field equations of general relativity;
- Stellar models;
- Introduction to cosmology;
- Hamiltonian formulation

**Intended learning outcomes**

The students are familiar with the basic physical and mathematical concepts of general relativity. They have a mathematical understanding of the formulation of general relativity on the basis of differential forms. They are able to apply the acquired knowledge to problems of Astrophysics and cosmology.

**Courses**

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment**

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, 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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Application-oriented Work Placement
(10 ECTS credits)
## Module Catalogue for the Subject Mathematics

### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internship (Lab Course) Applied Mathematics</td>
<td>10-M=EPRK-102-m01</td>
</tr>
</tbody>
</table>

### 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
Module can only be taken if a lecturer from the Institute of Mathematics agrees to supervise the placement. He or she will register the student for assessment.

### Contents
Work placement in economy, industry, research or administration.

### Intended learning outcomes
The student applies his/her skills obtained during his/her studies in the master programme to a specific practical problem in research, economy or industry.

### Courses
P (no information on SWS (weekly contact hours) and course language available)

### Method of assessment
Placement report / fieldwork report / report on practical training / report on practical course / project report / report on technical course / report on technical course (oral: approx. 30 to 60 minutes, written: approx. 10 to 30 pages)
Language of assessment: German, 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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Thesis

(30 ECTS credits)
Module title: Master Thesis Mathematics
Abbreviation: 10-M=MAAR-102-m01

Module coordinator: Dean of Studies Mathematik (Mathematics)
Module offered by: Institute of Mathematics

ECTS: 30
Method of grading: numerical grade
Only after succ. compl. of module(s): --

Duration: 1 semester
Module level: graduate
Other prerequisites: Registration for assessment and assignment of topic in consultation with supervisor. The supervisor may make the successful completion of certain modules that are relevant for the respective topic a prerequisite for the assignment of the topic.

Contents:
Independently researching and writing on a topic in mathematics selected in consultation with the supervisor.

Intended learning outcomes:
The student is able to work independently on a given mathematical topic and apply the skills and methods obtained during his/her studies in the master programme. He/She can write down the result of his/her work in a suitable form.

Courses (type, number of weekly contact hours, language — if other than German):
no courses assigned

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus):
written thesis
Language of assessment: German, 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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