Module Handbook
Mathematics Master 2016 (Master of Science (M.Sc.))
SPO 2016
Winter term 2024/25
Date: 09/07/2024

KIT DEPARTMENT OF MATHEMATICS
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1 Studies Plan

1.1 Qualification Objectives

Education within the Master's Program of Mathematics is aimed at qualifying students for professional activity in economy (in particular at banks, insurance companies, and consulting companies), industry (in particular in the area of simulation or interpretation of simulation results and in the area of software production for various needs), as well as for a scientific career (doctorate) in mathematics, engineering and natural sciences or economics. Research-based education prepares graduates for life-long learning.

1.1.1 Scientific Core Competencies

Graduates possess extended and in-depth knowledge in mathematics and, if applicable, in a complementary subject (Ergänzungsfach) that can be chosen freely. They are able to analyze and explain current, complex issues in these areas. They know the main mathematical disciplines (areas), their methodological approaches, and their mutual relationships. Graduates are able to define, describe, and interpret the specifics, limits, and terminologies in the areas chosen, to present the state of the art, and to further develop certain aspects of it.

1.1.2 Transferable Skills

Graduates can analyze topics from various perspectives. They can select and combine appropriate action alternatives for research-relevant topics. They can transfer and apply these approaches to specific problems. They can study in a differentiated manner complex problems and information as well as current requirements. They can analyze, compare, and evaluate them using suitable methods and concepts. Doing this, they estimate the complexity and risks, identify improvement potentials, and choose sustainable solution and improvement methods. As a result, they are in a position to make responsible and scientifically substantiated decisions. Scientific knowledge is used across disciplines taking into account social, scientific, and ethical findings. Graduates develop innovative ideas and can implement them. They can pursue these approaches either independently or in international teams. They are able to explain and discuss their decisions. They can also exchange opinions on a scientific level with representatives of their subject. They are in a position to interpret, validate, and illustrate the findings obtained. In particular, they can easily handle electronic media. Graduates are in a position to implement strategies for life-long learning and have developed pronounced stamina.

1.1.3 Learning Results

Graduates can name, explain, and independently apply specialized mathematical methods. They have an in-depth understanding of mathematical methods from at least two of the four areas of Algebra und Geometrie (algebra and geometry), Analysis (analysis), Angewandte und Numerische Mathematik (applied and numerical mathematics), and Stochastik (stochastics).

Depending on the subject, graduates have vast knowledge of special mathematical models and methods. This enables them to analyze complex and innovative problems in the respective area and to assess the results.

1.2 Organization of Studies

The study program is divided into subjects, the subjects are divided into modules, and the modules are divided into courses, with most modules consisting of a lecture (with or without exercise) or a seminar. Every module is completed by a control of success. The average work expenditure is measured in credits. Generally, modules are graded. Exceptions are e.g. seminar modules that may only be passed or failed. The master's thesis is a module of its own with 30 credits. In total, 120 credits have to be acquired within the Master's Program. These credits are to be distributed about homogeneously over four semesters.

1.3 Subjects, Areas, and Modules

The modules offered in the subjects are assigned to one of these four mathematical areas:

- Algebra und Geometrie (algebra and geometry),
- Analysis (analysis),
- Angewandte und Numerische Mathematik (applied and numerical mathematics),
- Stochastik (stochastics).

As a rule, no requirement is made as regards individual modules for the master's examination. However, in subject 1 “Mathematische Methoden 1” (mathematical methods 1), 24 credits have to be acquired in one of the four mathematical areas and in subject 2 “Mathematische Methoden 2” (mathematical methods 2), 16 credits have to be acquired in a second of the four areas. At least one of the areas chosen in these subjects must be Algebra und Geometrie (algebra and geometry) or Analysis (analysis). Only lecture modules and no seminars are permitted in both subjects.

In subject 3 “Ergänzungsfach” (complementary subject), modules in the total amount of 16 to 24 credits have to be passed. These modules have to be chosen either in one of the two mathematical areas not chosen in subject 1 and subject 2 or in
one of the subjects of **Informatik** (informatics), **Physik** (physics), **Wirtschaftswissenschaften** (economics), **Maschinenbau** (mechanical engineering) or **Elektrotechnik** (electrical engineering). Other subjects may be approved by the examination committee. If the modules are chosen from one of the mathematical areas, no seminars are permitted. The modules from informatics, physics, economics, mechanical engineering, or electrical engineering and information technology are offered by the respective Departments of Informatics, Physics, Economics, Mechanical Engineering or Electrical Engineering and Information Technology. It is possible to choose modules from the master’s program and the advanced bachelor’s program of the respective department. The modules permitted are listed in the module manual, others may be permitted by the examination committee. For some modules, registration for examination is possible only, if certain admission requirements specified in the module manual are met. It is strongly recommended to discuss the planned course of studies in the complementary subject with the subject’s study advisor, if no mathematical area is chosen as a complementary subject.

In subject 4 "Mathematisches Seminar" (mathematical seminar), two seminars of 3 credits each are required to obtain the necessary 6 credits as ungraded coursework.

In subject 5 "Mathematische Vertiefung" (mathematical specialization), modules in the amount of 14 to 22 credits have to be passed. The modules permitted in the above four mathematical areas are listed in the module manual. At the maximum, one ungraded seminar (with 3 credits) may be credited.

The credits of the modules passed in the subjects of “Ergänzungsfach” (complementary subject) and “Mathematische Vertiefung” (mathematical specialization) must total 38 at least.

Subject 6 “Überfachliche Qualifikation” (transferable skills) covers the additive acquisition of transferable skills in the amount of 6 credits (see Section 2.6). The attended courses may be graded or not graded. In any case, the grade will not be considered when calculating the total grade of the master's examination.

- **Subject 1:** Mathematische Methoden 1 (mathematical methods 1) (24 credits)
- **Subject 2:** Mathematische Methoden 2 (mathematical methods 2) (16 credits)
- **Subject 3:** Ergänzungsfach (complementary subject) (16 – 24 credits)
- **Subject 4:** Mathematisches Seminar (mathematical seminar) (6 credits)
- **Subject 5:** Mathematische Vertiefung (mathematical specialization) (14 – 22 credits)
- **Subject 6:** Überfachliche Qualifikation (transferable skills) (6 credits)
- **Master’s thesis** (30 credits)

The credit total of Ergänzungsfach (complementary subject) and Mathematische Vertiefung (mathematical specialization) must be 38 at least.

### 1.4 Introductory Modules in the Mathematical Areas

In the subjects, modules can be selected, which are particularly suited for introduction to the mathematical areas covered by the master’s program. The following modules are offered regularly, i.e. at least every second year, and correspond to a work expenditure of 8 credits (if not stated otherwise). The following abbreviations are used: SWS = Semesterwochenstunde in Vorlesung + Übung (hour per week per semester spent for lectures and exercises), Ws = Wintersemester (winter semester), Ss = Sommersemester (summer semester).

#### **Area of Algebra und Geometrie (algebra and geometry)**

- Algebra (algebra) (4+2 SWS, Ws)
- Differentialgeometrie (differential geometry) (4+2 SWS, Ss)
- Geometrische Gruppentheorie (geometrical group theory) (4+2 SWS, Ss)

The identically named courses assigned to the modules are offered annually and recommended to our students in the bachelor's program for specialization. If these courses have not been attended within the bachelor’s program, we recommend them as important introductory modules to the area of Algebra und Geometrie (algebra and geometry). If these modules have been attended within the bachelor’s program already, we recommend the following modules for introduction, for instance. The prerequisite for attending these modules is one introductory lecture indicated in the last brackets:

- Algebraische Zahlentheorie (algebraic number theory) (4+2 SWS) (prerequisite: Algebra (algebra))
- Algebraische Geometrie (algebraic geometry) (4+2 SWS) (prerequisite: Algebra (algebra))
- Globale Differentialgeometrie (global differential geometry) (4+2 SWS) (prerequisite: Differentialgeometrie (differential geometry))
- Algebraische Topologie (algebraic topology) (4+2 SWS)
- Stochastische Geometrie (stochastic geometry) (4+2 SWS, Ss) (prerequisite: Räumliche Stochastik (spatial stochastics))

The latter module can be assigned to the areas of Stochastik (stochastics) or Algebra und Geometrie (algebra and geometry).

#### **Area of Analysis (analysis)**

- Funktionalanalysis (functional analysis) (4+2 SWS, Ws)
- Spektraltheorie (spectral theory) (4+2 SWS, Ss)
- Klassische Methoden für partielle Differentialgleichungen (classical methods for partial differential equations) (4+2 SWS, Ws)
- Rand- und Eigenwertprobleme (boundary value and eigenvalue problems) (4+2 SWS, Ss)
Advanced Modules in the Mathematical Areas

The identically named courses assigned to the modules also are offered annually and recommended to our students of the bachelor's program for specialization. If they have not been attended within the bachelor's program, we recommend them as important introductory modules to the area of Analysis (analysis). If these modules have been attended within the bachelor's program already, we recommend the following modules for introduction, for instance. The prerequisite for attending these modules is one introductory lecture indicated in the last brackets.

- Evolutionsgleichungen (evolution equations) (4+2 SWS) (prerequisite: Funktionalanalyse (functional analysis))
- Harmonische Analysis (harmonic analysis) (4+2 SWS) (prerequisite: Funktionalanalyse (functional analysis))
- Integralgleichungen (integral equations) (4+2 SWS) (prerequisite: Funktionalanalyse (functional analysis))
- Geometrische Analysis (geometrical analysis) (4+2 SWS) (prerequisite: Klassische Methoden für partielle Differentialgleichungen (classical methods for partial differential equations))
- Randwertprobleme für nichtlineare Differentialgleichungen (boundary value problems for non-linear differential equations) (4+2 SWS) (prerequisite: Rand- und Eigenwertprobleme (boundary value and eigenvalue problems))

**Area of Angewandte und Numerische Mathematik (applied and numerical mathematics)**

- Numerische Methoden für Differentialgleichungen (numerical methods for differential equations) (4+2 SWS, Ws)
- Einführung in das Wissenschaftliche Rechnen (introduction to scientific computing) (3+3 SWS, Ss)
- Inverse Probleme (inverse problems) (4+2 SWS, Ws)

The latter module may be assigned to the area of Angewandte und Numerische Mathematik (applied and numerical mathematics) or to the area of Analysis (analysis). The identically named courses assigned to the modules are offered annually. All three modules can be chosen for specialization within the bachelor's program already. If they have not been attended within the bachelor's program, we recommend them as important introductory modules to the area of Angewandte und Numerische Mathematik (applied and numerical mathematics). If these modules have been attended within the bachelor's program already, we recommend the following modules for introduction, for instance. The prerequisite for attending these modules is one introductory lecture indicated in the last brackets. (Sometimes, additional analysis knowledge is required, which is specified in more detail in the corresponding module descriptions.)

- Finite Elemente Methoden (finite element methods) (4+2 SWS, Ws) (prerequisite: Numerische Methoden für Differentialgleichungen (numerical methods for differential equations))
- Numerische Optimierungsverfahren (numerical optimization methods) (4+2 SWS) (prerequisite: Optimierungstheorie (optimization theory) of the bachelor's program)
- Numerische Methoden für zeitabhängige partielle Differentialgleichungen (numerical methods for time-dependent partial differential equations) (4+2 SWS) (prerequisite: Numerische Methoden für Differentialgleichungen (numerical methods for differential equations))
- Numerische Methoden in der Finanzmathematik (numerical methods in financial mathematics) (4+2 SWS) (prerequisite: Numerische Methoden für Differentialgleichungen (numerical methods for differential equations))
- Spezielle Themen der Numerischen Linearen Algebra (special topics of numerical linear algebra) (4+2 SWS, Ss, is offered every two years)

**Area of Stochastik (stochastics)**

- Finanzmathematik in diskreter Zeit (financial mathematics in discrete time) (4+2 SWS, Ws)
- Finanzmathematik in stetiger Zeit (financial mathematics in continuous time) (4+2 SWS, Ss)
- Mathematische Statistik (mathematical statistics) (4+2 SWS, Ws)
- Räumliche Stochastik (spatial stochastics) (4+2 SWS, Ws)
- Stochastische Geometrie (stochastic geometry) (4+2 SWS, Ss) (prerequisite: Räumliche Stochastik (spatial stochastics))
- Zeitreihenanalyse (time series analysis) (2+1 SWS, 4 credits, Ss)

The module of Stochastische Geometrie (stochastic geometry) can be assigned to the area of Stochastik (stochastics) or the area of Algebra und Geometrie (algebra and geometry). The identically named courses assigned to the modules are offered annually. The following modules are also recommended for specialization.

- Mathematische Statistik (mathematical statistics) (2+1 SWS, 4 credits)
- Nichtparametrische Statistik (non-parametric statistics) (2+1 SWS, 4 credits)
- Der Poisson-Prozess (Poisson's process) (3+1 SWS, 6 credits)
- Brownsche Bewegung (Brownian motion) (2+1 SWS, 4 credits)
- Vorhersagen: Theorie und Praxis (predictions: theory and practice) (part 1: 2+1 SWS, 4 credits; part 2: 2+1 SWS, 4 credits)

1.5 Advanced Modules in the Mathematical Areas

The module manual lists a number of additional modules that are offered irregularly. These modules are based on the modules listed in the previous section and deepen the knowledge in the respective areas. Together with seminars, these modules enable students to write a master's thesis in a special area.
1.6 Transferable Skills

Transferable skills also are to be acquired during the studies. Transferable skills are imparted by cross-disciplinary courses on social topics, complementary scientific courses to convey use of scientific knowledge in daily working life, specific trainings of soft skills, and language trainings in the scientific context. The transferable skills conveyed integratively within the Master’s Program of Mathematics cover the following areas:

**Basic Competencies (soft skills)**

1. Team work, social communication (work in small groups, joint homework, and wrap-up of the lecture contents)
2. Preparation of presentations and presentation techniques (seminar presentations)
3. Logical and systematic argumentation and writing (in the tutorial or seminar, when preparing presentations and doing the homework)
4. English as a scientific language

**Orientation Knowledge**

1. Interdisciplinary knowledge on the application subject
2. Media, technology, and innovation

Apart from transferable skills that are imparted integratively, additive acquisition of transferable skills in the amount of 6 credits at least is envisaged. Within the module Überfachliche Qualifikationen (transferable skills), courses of the House of Competence (HoC), of the Language Center, or of the Center for Applied Cultural Sciences (ZAK) may be attended apart from the lecture *Einführung in Python* (*Introduction to Python*). Every semester, the course programs are updated. The contents are outlined in detail in the descriptions of the courses on the websites of HoC (https://www.hoc.kit.edu/index.php, in German only), ZAK (http://www.zak.kit.edu/english/), and the Language Center (https://www.spz.kit.edu/, in German only). In the module manual integrated here, the individual courses are not listed. Instead, an overview of the electives is given.

1.7 Student Mobility

Studies abroad are recommended, valued, and supported. To facilitate a stay abroad for the student's personal and scientific further development without a significant extension of the study duration, all examinations to be made are offered two times a year at least. At the student's request and if possible, another examination mode may be permitted in the individual case (e.g. oral instead of written examination), if this will prevent the study duration from being extended significantly as a result of a stay abroad. Study achievements made and examination results reached outside of KIT will be recognized, if the qualification to be replaced does not differ significantly from that to be credited. At the request of the student, the examination committee will decide on recognition. Students have to submit the proofs required for recognition. Conclusion of a learning agreement between the student and the examination committee is recommended prior to the stay abroad. In principle, a stay abroad is possible in every semester. The second and/or third semester is particularly suited for this purpose.

1.8 Exemplary Courses of Studies

In the following examples, modules from the four mathematical areas are chosen for the Ergänzungsfach (complementary subject). As credits in the range from 16 to 24 are to be acquired in the complementary subject, selection is quite easy.

**1.8.1 Example 1 (Start in the summer semester)**

**Semester 1:** 30 credits, 4 examinations, 2 courseworks

- Subject 1 (Analysis, analysis): Spektraltheorie (spectral theory) 8 credits
- Subject 2 (Stochastik, stochastics): Zeitreihenanalyse (time series analysis) 4 credits, Generalisierte Regressionsmodelle (generalized regression models) 4 credits
- Subject 3 (Algebra und Geometrie, algebra and geometry): Geometrische Gruppentheorie (geometrical group theory) 8 credits
- Subject 4 Mathematisches Seminar (mathematical seminar) 3 credits
- Subject 6 Überfachliche Qualifikation (transferable skill) 3 credits

**Semester 2:** 32 credits, 4 examinations

- Subject 1 (Analysis, analysis): Funktionalanalysis (functional analysis) 8 credits, Klassische Methoden für Partielle Differentialgleichungen (classical methods for partial differential equations) 8 credits
- Subject 2 (Stochastik, stochastics): Mathematische Statistik (mathematical statistics) 8 credits
- Subject 3 (Algebra und Geometrie, algebra and geometry): Geometrische Gruppentheorie 2 (geometrical group theory 2) 8 credits or Algebraische Topologie (algebraic topology) 8 credits

**Semester 3:** 28 credits, 3 examinations, 2 courseworks

- Subject 5 Mathematische Vertiefung (mathematical specialization): Finanzmathematik in stetiger Zeit (financial mathematics in continuous time), Einführung in das Wissenschaftliche Rechnen (introduction to scientific computing)
or Spezielle Themen der Numerischen Linearen Algebra (special topics of numerical linear algebra) with 8 credits each, special lecture with 6 credits, such as Perkolation (percolation) or Der Poissonprozess (Poisson’s process) or Numerische Verfahren für Maxwellgleichungen (numerical methods for Maxwell equations) or Geometrische Numerische Integration (geometrical numerical integration) or Steuerungstheorie (control theory)

- Subject 6 Überfachliche Qualifikation (transferable skill) 3 credits
- Subject 4 Mathematisches Seminar (mathematical seminar) 3 credits

### Semester 4: 30 credits
- Master’s thesis

#### Example 2 (Start in the summer semester)

### Semester 1: 30 credits, 3 examinations, 2 courseworks

- Subject 1 (Stochastik, stochastics): Finanzmathematik in stetiger Zeit (financial mathematics in continuous time) 8 credits, Statistical Learning 8 credits
- Subject 2 (Algebra und Geometrie, algebra and geometry): Geometrische Gruppentheorie (geometrical group theory) 8 credits
- Subject 4 Mathematisches Seminar (mathematical seminar) 3 credits
- Subject 6 Überfachliche Qualifikation (transferable skill) 3 credits

### Semester 2: 30 credits, 3 examinations, 2 courseworks

- Subject 1 (Stochastik, stochastics): Räumliche Stochastik (spatial stochastics) 8 credits
- Subject 2 (Algebra und Geometrie, algebra and geometry): Algebraische Topologie (algebraic topology) 8 credits
- Subject 3 (Angewandte und Numerische Mathematik, applied and numerical mathematics): Numerische Methoden für Differentialgleichungen (numerical methods for differential equations) 8 credits
- Subject 4 Mathematisches Seminar (mathematical seminar) 3 credits
- Subject 6 Überfachliche Qualifikation (transferable skill) 3 credits

### Semester 3: 30 credits, 4 examinations

- Subject 3 (Angewandte und Numerische Mathematik, applied and numerical mathematics): Einführung in das Wissenschaftliche Rechnen (introduction to scientific computing) 8 credits
- Subject 5 Mathematische Vertiefung (mathematical specialization): Stochastische Geometrie (stochastic geometry) 8 credits, Algebraische Topologie 2 (algebraic topology 2) 8 credits, special lecture 6 credits (or two seminars or one seminar and a special lecture of 3 credits)

### Semester 4: 30 credits
- Master’s thesis

#### 1.8.2 Example 3: (Start in the winter semester)

### Semester 1: 30 credits, 3 examinations, 2 courseworks

- Subject 1 (Algebra und Geometrie, algebra and geometry): Algebra (algebra) 8 credits, another module (Algebra und Geometrie, algebra and geometry) 8 credits
- Subject 2 (Analysis, analysis): Funktionalanalysis (functional analysis) 8 credits
- Subject 4 Mathematisches Seminar (mathematical seminar) 3 credits
- Subject 6 Überfachliche Qualifikation (transferable skill) 3 credits

### Semester 2: 30 credits, 3 examinations, 2 courseworks

- Subject 1 (Algebra und Geometrie, algebra and geometry): Geometrische Gruppentheorie (geometrical group theory) 8 credits
- Subject 2 (Analysis, analysis): Rand- und Eigenwertprobleme (boundary value and eigenvalue problems) 8 credits
- Subject 4 Mathematisches Seminar (mathematical seminar) 3 credits
- Subject 5 Mathematische Vertiefung (mathematical specialization): Geometrie der Schemata (geometry of schemes) 8 credits
- Subject 6 Überfachliche Qualifikation (transferable skill) 3 credits

### Semester 3: 30 credits, 4 examinations

- Subject 5 Mathematische Vertiefung (mathematical specialization): Geometrische Gruppentheorie 2 (geometrical group theory 2) 8 credits
- Subject 3 (Stochastik, stochastics): Mathematische Statistik (mathematical statistics) 8 credits, Räumliche Stochastik (spatial stochastics) 8 credits, Der Poissonprozess (Poisson’s process) 6 credits (or another course of 6 credits)

### Semester 4: 30 credits
### Example 4 (Start in the winter semester)

**Semester 1:** 30 credits, 3 examinations, 2 coursework

- Subject 1 (Analysis, analysis): Funktionalanalysis (functional analysis) 8 credits
- Subject 2 (Stochastik, stochastics): Räumliche Stochastik (spatial stochastics) 8 credits or Finanzmathematik in diskreter Zeit (financial mathematics in discrete time) 8 credits
- Subject 3 (Angewandte und Numerische Mathematik, applied and numerical mathematics): Numerische Methoden für Differentialgleichungen (numerical methods for differential equations) 8 credits
- Subject 4 Mathematisches Seminar (mathematical seminar) 3 credits
- Subject 6 Überfachliche Qualifikation (transferable skill) 3 credits

**Semester 2:** 30 credits, 3 examinations, 2 coursework

- Subject 1 (Analysis, analysis): Spektraltheorie (spectral theory) 8 credits
- Subject 2 (Stochastik, stochastics): Stochastische Geometrie (stochastic geometry) 8 credits or Finanzmathematik in stetiger Zeit (financial mathematics in continuous time) 8 credits
- Subject 3 (Angewandte und Numerische Mathematik, applied and numerical mathematics): Einführung in das Wissenschaftliche Rechnen (introduction to scientific computing) or Spezielle Themen der Numerischen Linearen Algebra (special topics of numerical linear algebra) 8 credits each
- Subject 4 Mathematisches Seminar (mathematical seminar) 3 credits
- Subject 6 Überfachliche Qualifikation (transferable skill) 3 credits

**Semester 3:** 30 credits, 4 examinations or 3 examinations + 2 coursework

- Subject 1 (Analysis, analysis): Klassische Methoden für Partielle Differentialgleichungen (classical methods for partial differential equations) 8 credits
- Subject 3 (Angewandte und Numerische Mathematik, applied and numerical mathematics): Finite Elemente Methoden (finite element methods) 8 credits
- Subject 5 Mathematische Vertiefung (mathematical specialization): module from Algebra und Geometrie (algebra and geometry) with 8 credits or Mathematische Statistik (mathematical statistics) 8 credits
- Subject 5 Mathematische Vertiefung (mathematical specialization): special lecture with 6 credits or two seminars with a total of 6 credits

**Semester 4:** 30 credits

- Master’s thesis
### 2 Field of study structure

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<td>Mathematical Methods 1</td>
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<td>Mathematical Methods 2</td>
<td>16 CR</td>
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<tr>
<td>Complementary Field</td>
<td>16-24 CR</td>
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| Mathematical Seminar  
This field will not influence the calculated grade of its parent. | 6 CR |
| Mathematical Specialization | 14-22 CR |
| Interdisciplinary Qualifications  
This field will not influence the calculated grade of its parent. | 6 CR |
| Voluntary | |
| Additional Examinations  
This field will not influence the calculated grade of its parent. | |

### 2.1 Master's Thesis

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| M-MATH-102917  
Master's Thesis | 30 CR |
2.2 Mathematical Methods 1

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<tr>
<td>Field Applied and Numerical Math</td>
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### 2.2.1 Field Algebra and Geometry
Part of: Mathematical Methods 1

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<td>Geometry of Schemes</td>
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<td>Global Differential Geometry</td>
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**Modelled Conditions**

The following conditions have to be fulfilled:

1. The field Mathematical Methods 2 / Field Algebra and Geometry must not have been started.
2. The field Complementary Field / Field Algebra and Geometry must not have been started.
2.2.2 Field Analysis
Part of: Mathematical Methods 1

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### Modelling Conditions

The following conditions have to be fulfilled:

1. The field **Mathematical Methods 2 / Field Analysis** must not have been started.
2. The field **Complementary Field / Field Analysis** must not have been started.
2.2.3 Field Applied and Numerical Mathematics
Part of: Mathematical Methods 1

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24
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Modelled Conditions
The following conditions have to be fulfilled:

1. The field Mathematical Methods 2 / Field Applied and Numerical Mathematics must not have been started.
2. The field Mathematical Methods 2 / Field Stochastics must not have been started.
3. The field Complementary Field / Field Applied and Numerical Mathematics must not have been started.
## 2.2.4 Field Stochastics

**Part of: Mathematical Methods 1**

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### Modelled Conditions

The following conditions have to be fulfilled:

1. The field Mathematical Methods 2 / Field Stochastics must not have been started.
2. The field Mathematical Methods 2 / Field Applied and Numerical Mathematics must not have been started.
3. The field Complementary Field / Field Stochastics must not have been started.
### 2.3 Mathematical Methods 2

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Part of: Mathematical Methods 2

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**Modelled Conditions**
The following conditions have to be fulfilled:

1. The field **Mathematical Methods 1 / Field Algebra and Geometry** must not have been started.
2. The field **Complementary Field / Field Algebra and Geometry** must not have been started.
2.3.2 Field Analysis
Part of: Mathematical Methods 2

Credits
16
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### Modelled Conditions

The following conditions have to be fulfilled:

1. The field **Mathematical Methods 1 / Field Analysis** must not have been started.
2. The field **Complementary Field / Field Analysis** must not have been started.
### 2.3.3 Field Applied and Numerical Mathematics

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## Field of Study Structure

**Mathematical Methods 2**

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<td>Modelling and Simulation of Lithium-Ion Batteries</td>
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<td>Scattering Theory for Time-dependent Waves</td>
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<td>Numerical Analysis of Neural Networks</td>
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<td>M-MATH-106682</td>
<td>Numerical Methods for Oscillatory Differential Equations</td>
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**Modelled Conditions**

The following conditions have to be fulfilled:

1. The field *Mathematical Methods 1 / Field Applied and Numerical Mathematics* must not have been started.
2. The field *Mathematical Methods 1 / Field Stochastics* must not have been started.
3. The field *Complementary Field / Field Applied and Numerical Mathematics* must not have been started.
2.3.4 Field Stochastics  
Part of: Mathematical Methods 2

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Modelled Conditions
The following conditions have to be fulfilled:

1. The field Mathematical Methods 1 / Field Stochastics must not have been started.
2. The field Mathematical Methods 1 / Field Applied and Numerical Mathematics must not have been started.
3. The field Complementary Field / Field Stochastics must not have been started.
### 2.4 Complementary Field

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<td>Field Applied and Numerical Mathematics</td>
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### 2.4.1 Field Algebra and Geometry

Part of: Complementary Field

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Field Algebra and Geometry (Election: at least 1 item as well as between 16 and 24 credits)

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**Modelled Conditions**

The following conditions have to be fulfilled:

1. The field **Mathematical Methods 1 / Field Algebra and Geometry** must not have been started.
2. The field **Mathematical Methods 2 / Field Algebra and Geometry** must not have been started.
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### Modelled Conditions
The following conditions have to be fulfilled:

1. The field *Mathematical Methods 1 / Field Analysis* must not have been started.
2. The field *Mathematical Methods 2 / Field Analysis* must not have been started.

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### 2.4.3 Field Applied and Numerical Mathematics

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Part of: Complementary Field
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**Modelled Conditions**
The following conditions have to be fulfilled:

1. The field Mathematical Methods 1 / Field Applied and Numerical Mathematics must not have been started.
2. The field Mathematical Methods 2 / Field Applied and Numerical Mathematics must not have been started.

### 2.4.4 Field Stochastics
**Part of: Complementary Field**

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**Modelled Conditions**
The following conditions have to be fulfilled:

1. The field Mathematical Methods 1 / Field Stochastics must not have been started.
2. The field Mathematical Methods 2 / Field Stochastics must not have been started.
## 2.4.5 Subject Computer Science

### Credits: 16-24

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## 2.4.6 Subject Physics

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### 2.7 Interdisciplinary Qualifications

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**Überfachliche Qualifikation (Election: at least 6 credits)**

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<td>M-MATH-106822</td>
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3 Modules

3.1 Module: Adaptive Finite Elemente Methods [M-MATH-102900]

Responsible: Prof. Dr. Willy Dörfler
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

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Mandatory

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<td>6 CR</td>
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Competence Certificate

oral exam of ca. 25 minutes

Prerequisites

none

Competence Goal

Participants

- know the necessity for using adaptive methods
- are able to explain the basic methods, techniques and algorithms for the treatment of elliptic boundary value problems with adaptive finite element methods
- can describe different approaches for error estimation
- are able to solve simple boundary value problems numerically

Content

- Necessity of adaptive methods
- Residual error estimator
- Aspects of implementations
- Optimality of adaptive methods
- Functional error estimator
- hp-Finite Elements

Module grade calculation

The grade of the module is the grade of the oral exam.

Workload

Total workload: 180 hours

Attendance: 60 h

- lectures, problem classes and examination

Self studies: 120 h

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research on the course content
- preparation for the module examination

Recommendation

Basic knowledge in finite element methods, in programming and analysis of boundary value problems is strongly recommended. Knowledge in functional analysis is recommended.
3.2 Module: Advanced Inverse Problems: Nonlinearity and Banach Spaces [M-MATH-102955]

**Responsible:** Prof. Dr. Andreas Rieder

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

| T-MATH-105927 | Advanced Inverse Problems: Nonlinearity and Banach Spaces | 5 CR | Rieder |

**Competence Certificate**

Success is assessed in the form of an oral examination lasting approx. 30 minutes.

**Prerequisites**
none

**Competence Goal**

Graduates are familiar with regularization methods for nonlinear ill-posed problems in Hilbert and Banach spaces and can discuss the underlying analytical and numerical aspects. They are also able to explain the conceptual differences between regularization methods in Hilbert and Banach spaces.

**Content**

- Inexact Newton methods in Hilbert spaces,
- Approximate Inverse in Banach spaces
- Tikhonov regularization with convex penalty
- Kaczmarz-Newton methods in Banach spaces

**Module grade calculation**

The module grade is the grade of the oral exam.

**Workload**

Total workload: 150 hours

- Attendance: 60 hours
  - lectures, problem classes, and examination
- Self-studies: 90 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

**Recommendation**

Inverse problems, Functional analysis
### 3.3 Module: Advanced Methods in Nonlinear Partial Differential Equations [M-MATH-106822]

**Responsible:** Prof. Dr. Wolfgang Reichel  
**Organisation:** KIT Department of Mathematics

#### Credits
- **M** 3

#### Grading scale
- Grade to a tenth

#### Recurrence
- Irregular

#### Duration
- 1 term

#### Language
- English

#### Level
- 4

#### Version
- 1

#### Mandatory

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<td>Advanced Methods in Nonlinear Partial Differential Equations</td>
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**Competence Certificate**  
The module examination takes place in form of an oral exam of about 30 minutes.

**Prerequisites**  
none

**Competence Goal**  
After successful completion of this module students

- know what amplitude or modulation equations are and can explain their significance;
- master several techniques to rigorously justify approximations by amplitude or modulation equations;
- have acquired miscellaneous methods to prove the existence of special solutions to nonlinear partial differential equations;
- can explain what the Ginzburg-Landau formalism is and how it can be employed to prove global existence of solutions.

**Content**  
Nonlinear partial differential equations describing physical phenomena are often complex, making their qualitative and quantitative analysis challenging. Amplitude or modulation equations, such as the Ginzburg-Landau equation, the Korteweg-de Vries equation, and the nonlinear Schrödinger equation, play an important role in capturing the critical dynamics of spatially extended dissipative or conservative physical models. Mathematical theorems demonstrate that these well-understood asymptotic models accurately predict the behavior of the original system on sufficiently long time scales. Examples which can be described in such a way include pattern-forming systems close to their first instability, the long-wave limit of the water wave problem, and highly oscillatory regimes in nonlinear optics.

In the first part of this course, we develop several methods to rigorously justify approximations of complex physical systems by amplitude or modulation equations. Relevant tools include Fourier analysis, energy estimates, semigroup theory, mode filters, and normal form transformations. Often, amplitude or modulation equations admit special solutions, such as Turing patterns, solitary waves, or traveling (modulating) fronts. While approximation results yield solutions of the original system that are close to these special solutions, they are insufficient to conclude that such special solutions exist in the original system as well. In the second part of this course, we focus on techniques, such as Lyapunov-Schmidt reduction, spatial dynamics, and center manifold reduction, to construct these special solutions in the original system.

**Module grade calculation**  
The module grade is the grade of the oral examination.
**Workload**
Total workload: 90 hours
Attendance: 30 hours
- lectures and examination

Self-studies: 60 hours
- follow-up and deepening of the course content,
- literature study and internet research relating to the course content,
- preparation for the module examination

**Recommendation**
The following modules are recommended: Analysis 1-3, Functional Analysis, Evolution Equations
3.4 Module: Algebra [M-MATH-101315]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Algebra and Geometry
Mathematical Methods 2 / Field Algebra and Geometry
Complementary Field / Field Algebra and Geometry
Mathematical Specialization
Additional Examinations

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Mandatory
T-MATH-102253 Algebra 8 CR Kühnlein, Sauer

Competence Certificate
Oral examination of ca. 30 minutes.

Prerequisites
None

Competence Goal
Students are able to

- understand essential concepts from Algebra,
- apply results from Galois theory to concrete situations,
- name basic results concerning discrete valuations and relate them to integral ring extensions.

They are prepared to write a thesis on a topic from algebra.

Content

- algebraic field extensions, Galois theory, roots of unit, applications of Galois theory
- discrete valuations, discrete valuation rings
- Tensor products of modules, integral ring extensions, normalization, noetherian rings, Hilbert's Basis Theorem

Module grade calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours.

Attendance: 90 h

- lectures and tutorials including the examination

Self studies: 150 h

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research on the course content
- preparation for the module examination

Recommendation
Basic knowledge on groups and rings is beneficial.
### 3.5 Module: Algebraic Geometry [M-MATH-101724]

**Responsible:** PD Dr. Stefan Kühnlein  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Complementary Field / Field Algebra and Geometry  
- Mathematical Specialization  
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**Mandatory**

| T-MATH-103340 | Algebraic Geometry | 8 CR | Herrlich, Kühnlein |

**Competence Certificate**  
The module will be completed by an oral exam of about 30 minutes.

**Prerequisites**  
None

**Competence Goal**  
Participants are able to

- name and discuss basic concepts concerning algebraic varieties  
- apply algebraic tools, in particular those from the theory of polynomial rings, to geometric questions  
- explain important results from classical algebraic geometry and their application in specific examples  
- start to read recent research papers from algebraic geometry and write a thesis in this area.

**Content**

- Hilbert's Nullstellensatz  
- affine and projective varieties  
- morphisms and rational maps  
- non-singular varieties  
- algebraic curves  
- Riemann-Roch-Theorem

**Module grade calculation**  
The module grade is the grade of the oral exam.

**Workload**  
**Total work load:**
- **Attendance:** 90 minutes  
  - lectures, problem classes an examination
  - Self studies: 150 hours  
    - follow-up and deepening of the course contents  
    - work on problem sheets  
    - literature study and internet research relating to the course contents  
    - Preparation of the oral exam

**Recommendation**  
The contents of basic courses on algebra and number theory, including basic commutative algebra, should be well-understood.
3.6 Module: Algebraic Number Theory [M-MATH-101725]

**Responsible:** PD Dr. Stefan Kühnlein

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Algebra and Geometry
- Complementary Field / Field Algebra and Geometry
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

| T-MATH-103346 | Algebraic Number Theory | 8 CR | Herrlich, Kühnlein |

**Competence Certificate**
oral examination of ca. 30 minutes

**Prerequisites**
none

**Competence Goal**
Students are able to

- understand basic structures and concepts from algebraic number theory,
- apply abstract concepts to concrete problems,
- read research papers and write a thesis in the field of algebraic number theory.

**Content**

- Algebraic number fields: rings of integers, Minkowski theory, class-groups and Dirichlet's unit theorem,
- Extensions of number fields: Ramified primes, Hilbert's ramification theory,
- Local fields: Ostrowski's theorem, valuation theory, Hensel's lemma, extensions of local fields,
- analytic methods: Dirichlet series, Dedekind's zeta function, L-series

**Module grade calculation**
The grade of the module is the grade of the oral exam.

**Workload**
Total workload: 240 hours

- Attendance: 90 h
  - lectures, problem classes and examination

- Self studies: 150 h
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research on the course content,
  - preparation for the module examination

**Recommendation**
The contents of the module "Algebra" are strongly recommended.
### 3.7 Module: Algebraic Topology [M-MATH-102948]

**Responsible:** Prof. Dr. Roman Sauer  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Complementary Field / Field Algebra and Geometry  
- Mathematical Specialization  
- Additional Examinations

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#### Mandatory

| T-MATH-105915 | Algebraic Topology | 8 CR | Krannich, Sauer |

**Prerequisites**

none
3.8 Module: Algebraic Topology II [M-MATH-102953]

**Responsible:** Prof. Dr. Roman Sauer

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Algebra and Geometry
- Complementary Field / Field Algebra and Geometry
- Mathematical Specialization
- Additional Examinations

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<td>Algebraic Topology II</td>
<td>8 CR</td>
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**Prerequisites**
none
3.9 Module: Algorithm Engineering [M-INFO-100795]

**Responsible:** Prof. Dr. Peter Sanders

**Organisation:** KIT Department of Informatics

**Part of:** Complementary Field / Subject Computer Science

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<td>Algorithm Engineering Pass</td>
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</table>

**Prerequisites**

There are two partial achievements Algorithm Engineering and Algorithm Engineering Exercises. The partial achievement Algorithm Engineering Exercises must be started to be allowed to take the oral examination for Algorithm Engineering.

**Competence Goal**

The students acquire a systematic understanding of algorithmic problems and solution approaches in the field of Algorithm Engineering, building on existing knowledge in the subject area of algorithms. In addition, they will be able to apply learned techniques to related problems and interpret and comprehend current research topics in the field of Algorithm Engineering.

Upon successful completion of the course, the student will be able to

- Explain terms, structures, basic problem definitions, and algorithms from the lecture;
- select which algorithms and data structures are suitable for solving an algorithmic problem and, if necessary, adapt them to the requirements of a specific problem;
- Execute algorithms and data structures, analyze them mathematically precise and prove the algorithmic properties;
- Explain machine models from the lecture and analyze algorithms and data structures according to these models
- Analyze new problems from applications, reduce them to their algorithmic core and create a suitable abstract model; based on the concepts and techniques learned in the lecture, design and analyze own solutions in this model, and prove algorithmic properties in this model.

**Content**

- What is Algorithm Engineering, Motivation etc.
- Realistic modeling of machines and applications
- practice-oriented algorithm design
- implementation techniques
- experimental techniques
- evaluation of measurements

The above skills are taught primarily using concrete examples. In the past these were for example the following topics from the area of basic algorithms and data structures:

- linked lists without special cases
- sorting: parallel, external, superscalar,...
- priority queues (cache efficient,...)
- search trees for integer keys
- Full text indexes
- graph algorithms: minimal spanning trees (external,...), route planning

In each of these cases, the focus is on the best known practical and theoretical methods. These usually differ considerably from the methods taught in beginners' lectures.
Workload
Lecture and exercise with a combined 3 semester hours, 5 ECTS
5 ECTS correspond to about 150h of work, split into
about 45h visiting lectures and exercise or block seminar
about 25h preparation and follow-up on lectures
about 40h solving exercise tasks (programming, preparing presentation for mini seminar, etc)
about 40h exam preparation
### 3.10 Module: Analytical and Numerical Homogenization [M-MATH-105636]

**Responsible:** TT-Prof. Dr. Roland Maier  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
- Additional Examinations  

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<td>Analytical and Numerical Homogenization</td>
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**Competence Certificate**  
Oral examination of approximately 30 minutes.

**Prerequisites**  
None.

**Competence Goal**  
The topic of the lecture are numerical multiscale methods presented exemplarily for elliptic problems. Students know the basic analytical results for existence and uniqueness of solutions to multiscale problems and from homogenization theory. In addition, they know methods for the numerical approximation of the multiscale and the homogenized solution. They are able to analyze the convergence of these methods and to assess the advantages and disadvantages of the different approaches.

**Content**  
- Analytical fundamentals (basic results from analysis for elliptic partial differential equations and from homogenization theory)  
- Approximation of the homogenized solution (e.g., Heterogeneous Multiscale Method)  
- Approximation of the multiscale solution (e.g., Localized Orthogonal Decomposition)

**Module grade calculation**  
The grade of the module is the grade of the oral exam.

**Annotation**  
The course is offered in English. If everybody speaks German, the lecture will be held in German.

**Workload**  
Total workload: 180 h  
Attendance: 60 h  
- Course including module examination during study.

Self-studies: 120 h  
- Deepening the study content by working on the lecture content at home  
- Working on exercises  
- In-depth study of the course content using suitable literature and Internet research,  
- preparation for the module examination during study.

**Recommendation**  
Basic knowledge of ordinary and/or partial differential equations as well as the contents of the module "Numerical Methods for Differential Equations" are strongly recommended. Knowledge of functional analysis is also recommended.

| Responsible: | Prof. Dr. Stefan Nickel |
| Organisation: | KIT Department of Economics and Management |
| Part of: | Complementary Field / Subject Economics |

### Compulsory Elective Courses (Election: between 1 and 2 items)

<table>
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### Supplementary Courses (Election: at most 1 item)

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### Competence Certificate

The assessment is carried out as partial exams (according to § 4(2), 1 of the examination regulation) of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module.

The assessment procedures are described for each course of the module separately.

The overall grade of the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

### Prerequisites

At least one of the courses Facility Location and strategic Supply Chain Management and Tactical and operational Supply Chain Management has to be taken.

### Competence Goal

The student

- is familiar with basic concepts and terms of Supply Chain Management,
- knows the different areas of Supply Chain Management and their respective optimization problems,
- is acquainted with classical location problem models (in the plane, on networks and discrete) as well as fundamental methods for distribution and transport planning, inventory planning and management,
- is able to model practical problems mathematically and estimate their complexity as well as choose and adapt appropriate solution methods.

### Content

Supply Chain Management is concerned with the planning and optimization of the entire, inter-company procurement, production and distribution process for several products taking place between different business partners (suppliers, logistics service providers, dealers). The main goal is to minimize the overall costs while taking into account several constraints including the satisfaction of customer demands.

This module considers several areas of Supply Chain Management. On the one hand, the determination of optimal locations within a supply chain is addressed. Strategic decisions concerning the location of facilities like production plants, distribution centers or warehouses are of high importance for the rentability of supply chains. Thoroughly carried out, location planning tasks allow an efficient flow of materials and lead to lower costs and increased customer service. On the other hand, the planning of material transport in the context of Supply Chain Management represents another focus of this module. By linking transport connections and different facilities, the material source (production plant) is connected with the material sink (customer). For given material flows or shipments, it is considered how to choose the optimal (in terms of minimal costs) distribution and transportation chain from the set of possible logistics chains, which asserts the compliance of delivery times and further constraints.

Furthermore, this module offers the possibility to learn about different aspects of the tactical and operational planning level in Supply Chain Management, including methods of scheduling as well as different approaches in procurement and distribution logistics. Finally, issues of warehousing and inventory management will be discussed.

### Annotation

The planned lectures and courses for the next three years are announced online.
Workload
The total workload of the module is about 240 hours. The workload is proportional to the credit points of the individual courses.

Recommendation
The courses Introduction to Operations Research I and II are helpful.
3.12 Module: Applications of Topological Data Analysis [M-MATH-105651]

**Responsible:** Dr. Andreas Ott

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Analysis
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Algebra and Geometry
- Complementary Field / Field Analysis
- Complementary Field / Field Stochastics
- Mathematical Specialization

**Additional Examinations**

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**Mandatory**

| T-MATH-111290 | Applications of Topological Data Analysis | 4 CR | Ott |

**Prerequisites**

None

**Responsible:** Dr.-Ing. Holger Jäkel

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** Complementary Field / Subject Electrical Engineering

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**Competence Certificate**

The success control takes place in the form of an oral examination lasting 25 minutes. Before the examination, there is a preparation phase of 15 minutes in which preparatory tasks are solved.

**Prerequisites**

none
Module: Aspects of Geometric Analysis [M-MATH-103251]

**Responsible:** Prof. Dr. Tobias Lamm

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Algebra and Geometry
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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**Competence Certificate**
oral exam; duration: about 20 minutes

**Prerequisites**
none

**Competence Goal**

- The students have got to know topics of Geometric analysis.
- They are able to use and explain the techniques they have learned in the course.

**Content**

Classical or recent topics of Geometric analysis, for example

- Geometric evolution equations,
- Geometric variational problems,
- The theory of minimal surfaces,
- Regularity of geometric objects,
- The isoperimetric problem,
- Spectral theory on manifolds.

**Recommendation**

Elementare Geometrie, Klassische Methoden partieller Differentialgleichungen/Partial differential equations, Functional analysis
# Module: Asymmetric Encryption Schemes [M-INFO-100723]

**Responsible:** Prof. Dr. Jörn Müller-Quade  
**Organisation:** KIT Department of Informatics  
**Part of:** Complementary Field / Subject Computer Science

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3.16 Module: Banach Algebras [M-MATH-102913]

**Responsible:** PD Dr. Gerd Herzog

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

| T-MATH-105886 | Banach Algebras | 3 CR | Herzog |

**Competence Certificate**
The module will be completed by an oral exam (about 20 min).

**Prerequisites**
none

**Competence Goal**
At the end of the course, students can

- name, discuss and apply basic statements of the theory of Banach algebras,
- use specific techniques from ideal theory, spectral theory and functional calculus in Banach algebras.

**Content**

1. Banach and operator algebras
2. Multiplicative linear functionals
3. Spectrum and resolvents
4. Commutative Banach algebras
5. Corona Theorem
6. Functional calculus in Banach algebras
7. \( \mathcal{B}^{*} \)-algebras
8. Ordered Banach algebras

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**

Total workload: 90 hours

- Attendance: 30 hours
  - lectures, problem classes, and examination

- Self-studies: 60 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

**Recommendation**
Knowledge of complex analysis (e.g. from Analysis 4) is recommended.
### 3.17 Module: Batteries and Fuel Cells [M-ETIT-100532]

**Responsible:** Prof. Dr.-Ing. Ulrike Krewer  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Complementary Field / Subject Electrical Engineering

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**Mandatory**

| T-ETIT-100983 | Batteries and Fuel Cells | 5 CR | Krewer |

**Prerequisites**

none
### 3.18 Module: Bayesian Inverse Problems with Connections to Machine Learning [M-MATH-106328]

**Responsible:** TT-Prof. Dr. Sebastian Krumscheid  
**Organisation:** KIT Department of Mathematics  
**Part of:** Mathematical Methods 1 / Field Applied and Numerical Mathematics  
Mathematical Methods 2 / Field Applied and Numerical Mathematics  
Complementary Field / Field Applied and Numerical Mathematics  
Mathematical Specialization  
Additional Examinations

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<td>4</td>
<td>Krumscheid</td>
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</table>

**Competence Certificate**  
oral exam of ca. 30 min

**Prerequisites**  
None

**Competence Goal**  
After completing the module's classes and the exam, students will be familiar with the theory of inverse problems. They will be able to apply the Bayesian framework to a given inverse problem and assess the well-posedness of the Bayesian posterior. In addition, students will be able to describe the basics of several solution methods for accessing the Bayesian posterior, including approximation and machine-learning techniques, and their limitations. Finally, they will be able to name and discuss essential theoretical concepts for Bayesian inversion in Banach spaces and describe the suitable sampling-based solution techniques. In particular, the course prepares students to write a thesis in the field of Uncertainty Quantification.

**Content**  
The course offers an introduction to the subject of statistical inversion, where, in its most basic form, the goal is to study how to estimate model parameters from data. We will introduce mathematical concepts and computational tools for systematically treating these inverse problems in a Bayesian framework, including an assessment of how uncertainties affect the solution. In the first part of the course, we will study the Bayesian framework for finite-dimensional inverse problems. While the first part will introduce some machine-learning ideas, the second part will address how machine learning is impacting, and has the potential to impact further on, the subject of inverse problems. In the final part of the course, we will generalize the Bayesian inverse problem theory to a Banach space setting and discuss sampling strategies for accessing the Bayesian posterior.

Topics covered include:
- Bayesian Inverse Problems and Well-Posedness
- The Linear-Gaussian Setting
- Optimization Perspective on Bayesian Inverse Problems
- Gaussian Approximation
- Markov Chain Monte Carlo
- Blending Inverse Problems and Machine-Learning
- Bayesian Inversion in Banach spaces

**Module grade calculation**  
The grade of the module is the grade of the oral exam.

**Workload**  
total workload: 120 hours

**Recommendation**  
The contents of the modules 'M-MATH-101321 - Introduction to Stochastics', 'M-MATH-103214 – Numerical Mathematics 1+2', and 'M-MATH-106053 — Stochastic Simulation' are recommended.
Module: Bifurcation Theory [M-MATH-103259]

**Responsible:** Dr. Rainer Mandel

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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**Prerequisites**
None

**Annotation**
Course is held in English
Module: Bott Periodicity [M-MATH-104349]

Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Algebra and Geometry
Mathematical Methods 2 / Field Algebra and Geometry
Complementary Field / Field Algebra and Geometry
Mathematical Specialization
Additional Examinations

Credits: 5
Grading scale: Grade to a tenth
Recurrence: Irregular
Duration: 1 term
Level: 4
Version: 1

Mandatory
T-MATH-108905 Bott Periodicity 5 CR Tuschmann

Prerequisites
None
Module: Boundary and Eigenvalue Problems [M-MATH-102871]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of:
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

Credits: 8
Grading scale: Grade to a tenth
Recurrence: Each summer term
Duration: 1 term
Level: 4
Version: 1

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<tr>
<td>T-MATH-105833</td>
<td>Boundary and Eigenvalue Problems</td>
<td>8 CR</td>
</tr>
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</table>

Competence Certificate
The module will be completed by an oral exam (approx. 30 min).

Prerequisites
None

Competence Goal
Graduates will be able to

- assess the significance of boundary value and eigenvalue problems within mathematics and/or physics and illustrate them using examples,
- describe qualitative properties of solutions,
- prove the existence of solutions to boundary value problems using functional analysis methods,
- make statements about the existence of eigenvalues and eigenfunctions of elliptic differential operators and describe their properties.

Content

- Examples of boundary and eigenvalue problems
- Maximum principles for 2nd order equations
- Function spaces, e.g. Sobolev spaces
- Weak formulation of 2nd order linear elliptic equations
- Existence and regularity theory for elliptic equations
- Eigenvalue theory for weakly formulated elliptic eigenvalue problems

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours
- lectures, problem classes, and examination

Self-studies: 150 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination
3.22 Module: Boundary Element Methods [M-MATH-103540]

Responsible: PD Dr. Tilo Arens
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization

Credits: 8
Grading scale: Grade to a tenth
Recurrence: Irregular
Duration: 1 term
Level: 4
Version: 1

Mandatory
T-MATH-109851 Boundary Element Methods 8 CR Arens

Competence Certificate
The examination is carried out by an oral examination (approx. 30 minutes).

Prerequisites
None

Competence Goal
Students are able to apply the analytic foundations of defining potentials and boundary operators, such as distributions, Sobolev spaces on boundaries of Lipschitz domains and trace operators to specific problems. They understand the definition of potentials, boundary operators and important mathematical statements about them. They are able to formulate boundary integral equations for concrete elliptic boundary value problems and to comprehend the proofs for their solvability.

Students are able to name and describe classes of boundary elements. They are familiar with the use of various boundary elements for numerically solving boundary integral equations by Galerkin methods. They can explain results on convergence of such methods. The students can describe techniques for improving practical handling of boundary element methods such as matrix compression schemes and preconditioning.

Content
- Sobolev spaces
- function spaces on Lipschitz boundaries
- boundary value problems for elliptic partial differential equations
- potentials and boundary operators
- boundary integral equations
- boundary elements
- Galerkin boundary element methods
- preconditioning
- matrix compression

Module grade calculation
The module grade is the grade of the oral examination.

Workload
Total workload: 240 hours
Attendance: 90 h
- lectures, problem classes and examination
Self studies: 150 h
- increased understanding of module content by wrapping up lectures at home
- work on exercises
- increased understanding of module content by self study of literature and internet research
- preparing for the examination
Recommendation
We recommend attendance of the module "Numerical Methods for Integral Equations".
3.23 Module: Boundary value problems for nonlinear differential equations [M-MATH-102876]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of:
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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</table>

Plum, Reichel

Competence Certificate
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
None

Competence Goal
Graduates will be able to

- assess the significance of non-linear boundary value problems in relation to their applications in the natural and engineering sciences and illustrate them using examples,
- describe qualitative properties of solutions,
- prove the existence of solutions using functional analytical methods,
- recognize and analyze non-linear phenomena (e.g. bifurcation, multiplicity of solutions) and illustrate them using prototypical examples.

Content

- Method of upper and lower solutions
- Existence using fixed point methods
- Qualitative properties
- Variational methods and/or bifurcation theory

Module grade calculation
The module grade is the grade of the oral/written exam.

Workload
Total workload: 240 hours
Attendance: 90 hours
- lectures, problem classes, and examination
Self-studies: 150 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendation
The contents of the courses 'Functional Analysis', 'Classical Methods for Partial Differential Equations' and 'Boundary and Eigenvalue Problems' are recommend.
Module: Brownian Motion [M-MATH-102904]

Responsible: Prof. Dr. Nicole Bäuerle
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Stochastics
Mathematical Methods 2 / Field Stochastics
Complementary Field / Field Stochastics
Mathematical Specialization

Credits: 4
Grading scale: Grade to a tenth
Recurrence: Irregular
Duration: 1 term
Level: 4
Version: 1

Mandatory

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T-MATH-105868 Brownian Motion

4 CR Bäuerle, Fasen-Hartmann, Last

Competence Certificate

The module will be completed by an oral exam (about 20 min).

Prerequisites

none

Competence Goal

At the end of the course, students

• can name, explain and justify properties of the Brownian motion,
• can use the Brownian motion to model stochastic phenomenon,
• can use specific probabilistic techniques,
• are able to work in a self-organized and reflective manner.

Content

• Existence and construction of Brownian motion,
• path properties of Brownian motion,
• strong Markov property of Brownian motion with applications,
• Skorokhod representation theorems with Brownian motion.

Module grade calculation

The module grade is the grade of the oral exam.

Workload

Total workload: 120 hours
Attendance: 45 hours

• lectures, problem classes, and examination

Self-studies: 72 hours

• follow-up and deepening of the course content,
• work on problem sheets,
• literature study and internet research relating to the course content,
• preparation for the module examination

Recommendation

The course ‘Probability Theory’ is strongly recommended.
### 3.25 Module: Classical Methods for Partial Differential Equations [M-MATH-102870]

**Responsible:** Prof. Dr. Wolfgang Reichel  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 2 / Field Analysis  
- Complementary Field / Field Analysis  
- Mathematical Specialization  
- Additional Examinations

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<td>Frey, Hundertmark, Lamm, Plum, Reichel, Schnaubelt</td>
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**3.26 Module: Coding Theory [M-INFO-106824]**

**Responsible:** Prof. Dr. Jörn Müller-Quade  
**Organisation:** KIT Department of Informatics  
**Part of:** Complementary Field / Subject Computer Science

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<th>Duration</th>
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<td>Coding Theory</td>
<td>3 CR</td>
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</tbody>
</table>

**Competence Certificate**  
See partial achievements (Teilleistung)

**Prerequisites**  
See partial achievements (Teilleistung)

**Competence Goal**  
The student  
• can name and explain the methods of coding theory;  
• assesses various quality characteristics and parameters of codes;  
• assesses the practical significance of theoretical barriers for codes;  
• analyzes given systems and adapts them to changing conditions.

**Content**  
This lecture mainly deals with channel coding. It examines how signals can be protected against random noise affecting the transmission channel. Bounds of codes (Hamming, Gilbert-Varshamov, Singleton) are presented. In addition to the coding and decoding of classical algebraic codes (linear, Reed Solomon, Goppa and Reed Muller codes), concatenated codes and sums of codes are also covered. In addition, a connection to cryptography, in particular the McEliece encryption method, is established.

**Workload**  
Attendance time in the lecture: 24 h  
Preparation and follow-up of the same: 24 h  
Exam preparation and attendance in the same: 42 h
3.27 Module: Combinatorics [M-MATH-102950]

**Responsible:** Prof. Dr. Maria Aksenovich

**Organisation:** KIT Department of Mathematics

**Part of:** Mathematical Methods 1 / Field Algebra and Geometry
Mathematical Methods 2 / Field Algebra and Geometry
Complementary Field / Field Algebra and Geometry
Mathematical Specialization

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**Credits:** 8

**Grading scale:** Grade to a tenth

**Recurrence:** see Annotations

**Duration:** 1 term

**Language:** English

**Level:** 4

**Version:** 3

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### Mandatory

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<td>Combinatorics</td>
<td>8 CR</td>
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</table>

**Competence Certificate**

The final grade is given based on the written final exam (2h).

By successfully working on the problem sets, a bonus can be obtained. To obtain the bonus, one has to achieve 50% of the points on the solutions of the exercise sheets 1-6 and also of the exercise sheets 7-12. If the grade in the final written exam is between 4,0 and 1,3, then the bonus improves the grade by one step (0,3 or 0,4).

**Prerequisites**

none

**Competence Goal**

The students understand, describe, and use fundamental notions and techniques in combinatorics. They can analyze, structure, and formally describe typical combinatorial questions. The students can use the results and methods such as inclusion-exclusion, generating functions, Young tableaux, as well as the developed proof ideas, in solving combinatorial problems. In particular, they can analyze the existence and the number of ordered and unordered arrangements of a given size. The students understand and critically use the combinatorial methods. Moreover, the students can communicate using English technical terminology.

**Content**

The course is an introduction into combinatorics. Starting with counting problems and bijections, classical methods such as inclusion-exclusion principle and generating functions are discussed. Further topics include Catalan families, permutations, Young tableaux, partial orders, and combinatorial designs.

**Module grade calculation**

The grade of the module is the grade of the written exam.

**Annotation**

- Regular cycle: every 2nd year, summer semester
- Course is held in English

**Workload**

Total workload: 240 hours

Attendance time: 90 hours

- Course including module examination during the course of study

Self-study: 150 hours

- Deepening the study content by working on the lecture content at home
- Completion of exercises
- In-depth study of the course content using suitable literature and internet research
- Preparation for the module examination during the course of study

**Recommendation**

Knowledge of the modules Linear Algebra 1 and 2 and Analysis 1 and 2 is recommended.
### Module: Communications Engineering II [M-ETIT-105274]

**Responsible:** Dr.-Ing. Holger Jäkel  
Prof. Dr.-Ing. Laurent Schmalen

**Organisation:**  
KIT Department of Electrical Engineering and Information Technology  
Part of: Complementary Field / Subject Electrical Engineering

<table>
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<th>Credits</th>
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<th>Recurrence</th>
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<th>Language</th>
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<td>Each term</td>
<td>1 term</td>
<td>German/English</td>
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**Mandatory**

| T-ETIT-110697 | Communications Engineering II | 4 CR | Jäkel, Schmalen |

**Competence Certificate**  
The assessment will be carried out in the form of a written exam of 120 minutes.

**Prerequisites**  
none

**Competence Goal**  
The students are able to analyze even more complex problems in communications engineering. You can independently develop and validate solutions and use problem-solving software. The transfer of the learned methods enables the students to quickly grasp other topics and to work on them with the appropriate methodological knowledge.

**Content**

The course broadens the questions dealt with in the lecture Communication Engineering I. The focus here is on the detailed analysis of known algorithms and the introduction of new methods that were not discussed in the lecture Communications Engineering I, especially in the areas of system and channel modeling, equalization and synchronization.

**Module grade calculation**  
The module grade is the grade of the written exam.

**Annotation**

Please note: The course "Nachrichtentechnik II" (in German) takes place every summer semester and the English version "Communications Engineering II" takes place every winter semester.

In the future, the module will be divided into an English Master's course (from winter term 25/26) and a German Bachelor's course (from summer term 2025). Both will comprise 6 CP each.

**Workload**

1. Attendance Lecture: 15 * 2 h = 30 h  
2. Preparation / Postprocessing Lecture: 15 * 4 h = 60 h  
3. Presence Exercise: 15 * 1 h = 15 h  
4. Preparation / follow-up Exercise: 15 * 2 h = 30 h  
5. Exam preparation and presence in the same: charged in preparation / follow-up  
Total: 135 h = 4 LP

**Recommendation**

Knowledge of basic engineering mathematics including integral transformations and probability theory as well as basic knowledge of communications engineering.

Previous visit to the lecture "Communications Engineering I", "Probability Theory" and "Signals and Systems" is recommended.
### 3.29 Module: Comparison Geometry [M-MATH-102940]

**Responsible:** Prof. Dr. Wilderich Tuschmann  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Complementary Field / Field Algebra and Geometry  
- Mathematical Specialization  
- Additional Examinations

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<td>T-MATH-105917</td>
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</table>

**Prerequisites**
none

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Mathematics Master 2016 (Master of Science (M.Sc.))
Module Handbook as of 09/07/2024
### 3.30 Module: Complex Analysis [M-MATH-102878]

**Responsible:** PD Dr. Gerd Herzog  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 2 / Field Analysis  
- Complementary Field / Field Analysis  
- Mathematical Specialization  
- Additional Examinations

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**Mandatory**  
- T-MATH-105849 Complex Analysis

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<tr>
<td>8</td>
<td>Complex Analysis</td>
<td>Herzog, Plum, Reichel, Schnaubelt, Tolksdorf</td>
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</table>

**Competence Certificate**  
The module will be completed by an oral exam (about 30 min).

**Prerequisites**  
None

**Competence Goal**  
At the end of the course, students can
- explain the basic concepts and results of the theory of infinite products and apply them in examples within the framework of Weierstrass's theorems
- reproduce the Mittag-Leffler theorem and derive conclusions from it
- explain Riemann's mapping theorem and are able to describe what Montel's theorem is and how this theorem is included in the proof of Riemann's theorem
- name the most important properties of class $S$ of simple functions and formulate the (proven) Bieberbach conjecture
- can explain the basic concepts of the theory of harmonic functions and apply them in examples
- explain the Schwarz reflection principle.
- describe properties of regular and singular points in power series and discuss them with examples.

**Content**  
- infinite products
- Mittag-Leffler's theorem
- Montel's theorem
- Riemann's mapping theorem
- conformal mappings
- univalent (schlicht) functions
- automorphisms of some domains
- harmonic functions
- Schwarz reflection principle
- regular and singular points of power series

**Module grade calculation**  
The module grade is the grade of the oral exam.
Workload
Total workload: 240 hours
Attendance: 90 hours
  • lectures, problem classes, and examination
Self-studies: 150 hours
  • follow-up and deepening of the course content,
  • work on problem sheets,
  • literature study and internet research relating to the course content,
  • preparation for the module examination

Recommendation
Basics of complex analysis, for example from the “Analysis 4” module, are recommended.
3.31 Module: Complex Geometry [M-MATH-106776]

**Responsible:** Jun.-Prof. Dr. Claudio Llosa Isenrich

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Algebra and Geometry
- Complementary Field / Field Algebra and Geometry
- Mathematical Specialization
- Additional Examinations

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<td>Complex Geometry</td>
<td>6 CR</td>
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**Competition Certificate**
The module will be completed by an oral exam (of ca. 30 min).

**Prerequisites**
None

**Competence Goal**
Graduates
- can understand the structure of complex geometry and apply its results to specific problems;
- are able to explain important results on compact Kähler manifolds and their topology, relate them to each other and apply them to examples;
- can sketch proofs of important results from the lecture;
- can work in a self-organized and reflective manner.

**Content**
- Introduction to complex analysis in several variables
- Complex manifolds, vector bundles and forms
- Introduction to Kähler manifolds and important examples
- The Kähler identities and their consequences
- Dolbeaut cohomology and the Hodge decomposition theorem

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 180 hours

- Attendance: 60 hours
  - lectures and examination

- Self-studies: 120 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

**Recommendation**
Knowledge of complex analysis (e.g. "Analysis 4") and differential geometry is strongly recommended. The same applies to the contents of the modules "Elementary Geometry" and "Introduction to Algebra and Number Theory".
3.32 Module: Compressive Sensing [M-MATH-102935]

**Responsible:** Prof. Dr. Andreas Rieder

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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**Competence Certificate**

Success is assessed in the form of an oral examination lasting approx. 30 minutes.

**Competence Goal**

Graduates can explain the ideas of compressive sensing and can name areas of application. They can apply and compare the basic algorithms and analyze their convergence behavior.

**Content**

- What is compressive sensing and where is it used?
- Sparse solutions of underdetermined linear systems of equations
- Basic algorithms
- Restricted isometry property
- Sparse solutions of underdetermined linear systems of equations with random matrices

**Module grade calculation**

The module grade is the grade of the oral exam.

**Workload**

Total workload: 150 hours

- Attendance: 60 hours
  - lectures, problem classes, and examination

- Self-studies: 90 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

**Recommendation**

The course “Introduction to stochastics” is recommended.
3.33 Module: Computational Fluid Dynamics and Simulation Lab [M-MATH-106634]

**Responsibility:** PD Dr. Gudrun Thäter

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

**Credits:** 4

**Grading scale:** Grade to a tenth

**Recurrence:** Each summer term

**Duration:** 1 term

**Language:** German/English

**Level:** 4

**Version:** 2

**Mandatory**

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**Competence Certificate**
For their final project, students prepare a written report, usually 10-15 pages long, which is graded.

**Prerequisites**
none

**Competence Goal**
Students are able to jointly model problems beyond their own discipline and simulate them on high-performance computers. They have acquired a critical distance to results and their presentation. They can defend the results of projects in disputes. They have understood the importance of stability, convergence and parallelism of numerical methods from their own experience and are able to evaluate errors in modeling, approximation, computing and presentation.

**Content**

**Lecture part:** Introduction to modeling and simulations, introduction to associated numerical methods, introduction to associated software and high-performance computer hardware

**Own group work:** Working on 1-2 projects in which modelling, discretization, simulation and evaluation (e.g. visualization) are carried out for specific topics from the catalog. The catalog includes e.g: Diffusion processes, turbulent flows, multiphase flows, reactive flows, particle dynamics, optimal control and optimization under constraints, stabilization methods for advection-dominated transport problems.

**Module grade calculation**
The module grade is the grade of the final project.

**Workload**
Total workload: 120 hours

- Attendance: 60 hours
  - lectures and examination

- Self-studies: 60 hours
  - follow-up and deepening of the course content,
  - work on projects and report,
  - literature study and internet research relating to the course content

**Recommendation**
Basic knowledge of the analysis of boundary value problems and of numerical methods for differential equations is recommended. Knowledge of a programming language is strongly recommended.
### 3.34 Module: Computational Geometry [M-INFO-102110]

**Responsible:** TT-Prof. Dr. Thomas Bläsius  
**Organisation:** KIT Department of Informatics  
**Part of:** Complementary Field / Subject Computer Science

<table>
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<th>Duration</th>
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**Mandatory**

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<td>T-INFO-104429</td>
<td>Computational Geometry</td>
<td>6</td>
<td>Bläsius</td>
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</table>
### 3.35 Module: Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems [M-MATH-102883]

**Responsible:** Prof. Dr. Michael Plum  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 2 / Field Analysis  
- Complementary Field / Field Analysis  
- Mathematical Specialization  
- Additional Examinations

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</table>
Module: Continuous Time Finance [M-MATH-102860]

**Responsible:** Prof. Dr. Nicole Bäuerle

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

**Credits**: 8

**Grading scale**: Grade to a tenth

**Recurrence**: Each summer term

**Duration**: 1 term

**Level**: 4

**Version**: 1

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**Mandatory**

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<td>T-MATH-105930</td>
<td>Continuous Time Finance</td>
<td>8 CR</td>
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</table>

**Competence Certificate**

oral examination of ca. 30 min.

**Prerequisites**
The module cannot be completed together with "Stochastic Calculus and Finance [T-WIWI-103129]".

**Competence Goal**

Students are able to

- understand, describe and use fundamental notions and techniques of modern continuous time finance,
- use specific probabilistic techniques,
- analyze mathematically economical questions in option pricing and optimization

**Content**

- Stochastic processes and filtrations
  - Martingales in continuous time
  - Stopping times
  - Quadratic variation
- Stochastic Ito-Integral w.r.t. continuous semimartingales
- Ito-calculus
  - Ito-Doebelin formula
  - Stochastic exponentials
  - Girsanov theorem
  - Martingale representation
- Black-Scholes financial market
  - Arbitrage and equivalent martingale measures
  - Options and no-arbitrage prices
  - market completeness
- Portfolio optimization
- Bonds, forwards and interest rate models

**Module grade calculation**
The grade of the module is the grade of the oral exam.
Workload
Total workload: 240 hours
Attendance: 90 h
  - lectures, problem classes and examination
Self studies: 150 h
  - follow-up and deepening of the course content,
  - work on problem sheets
  - literature study and internet research on the course content,
  - preparation for the module examination

Recommendation
The content of the module „Probability theory“ is strongly recommended. The module „Discrete time finance“ is recommended.
Module: Control Theory [M-MATH-102941]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Analysis
Mathematical Methods 2 / Field Analysis
Complementary Field / Field Analysis
Mathematical Specialization
Additional Examinations

Credits: 6
Grading scale: Grade to a tenth
Recurrence: Irregular
Duration: 1 term
Language: German/English
Level: 4
Version: 1

Mandatory

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<th>Grade</th>
<th>Recurrence</th>
<th>Duration</th>
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</table>

Competence Certificate
The module will be completed by an oral exam (ca. 20 min).

Prerequisites
none

Competence Goal
Students can explain the central concepts of the treatment of controlled linear ordinary differential equations (controllability, observability, stabilizability and discoverability) and the associated characterizations and apply them in examples. They are able to describe the basic features of the theory of transfer functions and realization theory. They can discuss the solution of the quadratic optimal control problem and apply it to feedback synthesis. They can describe the basic concepts of control theory including the associated criteria also for non-linear systems and apply them to examples.

Content
- controllability and observability of systems of linear ordinary differential equations
- stabilizability and detectability
- transfer functions
- realization theory,
- quadratic optimal control, feedback synthesis
- nonlinear control theory: basic concepts, criteria via linearization, Lie brackets and Lyapunov functions

Module grade calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 180 hours
Attendance: 60 h
- lectures, problem classes and examination
Self studies: 120 h
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendation
The contents of the modules Analysis 1-2 and Lineare Algebra 1-2 are strongly recommended. Further knowledge of ordinary differential equations (as in Analysis 4) is useful.

Literature
3.38 Module: Convex Geometry [M-MATH-102864]

**Responsible:** Prof. Dr. Daniel Hug

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Algebra and Geometry
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

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<td>Version</td>
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**Mandatory**

| T-MATH-105831 | Convex Geometry | 8 CR | Hug |

**Competence Certificate**
The module will be completed by an oral exam (ca. 30 min).

**Prerequisites**
None

**Competence Goal**
The students
- know fundamental combinatorial, geometric and analytic properties of convex sets and convex functions and apply these to related problems,
- are familiar with fundamental geometric and analytic inequalities for functionals of convex sets and their applications to geometric extremal problems and can present central ideas and techniques of proofs,
- know selected integral formulas for convex sets and the required results on invariant measures.
- know how to work self-organized and self-reflexive.

**Content**

1. Convex Sets
   1.1. Combinatorial Properties
   1.2. Support and Separation Properties
   1.3. Extremal Representations
2. Convex Functions
   2.1. Basic Properties
   2.2. Regularity
   2.3. Support Function
3. Brunn-Minkowski Theory
   3.1. Hausdorff Metric
   3.2. Volume and Surface Area
   3.3. Mixed Volumes
   3.4. Geometric Inequalities
   3.5. Surface Area Measures
   3.6. Projection Functions
4. Integralgeometric Formulas
   4.1. Invariant Measures
   4.2. Projection and Section Formula
   4.3 Kinematic Formula

**Module grade calculation**
The module grade is the grade of the oral exam.
**Workload**
Total workload: 240 hours

**Attendance:** 90 hours
- lectures, problem classes, and examination

**Self-studies:** 150 hours
- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research related to the course content
- preparation for the module exam.

**Literature**
Module: Curves on Surfaces [M-MATH-106632]

 Responsible: Dr. Elia Fioravanti
 Organisation: KIT Department of Mathematics
 Part of: Mathematical Methods 1 / Field Algebra and Geometry
 Mathematical Methods 2 / Field Algebra and Geometry
 Complementary Field / Field Algebra and Geometry
 Mathematical Specialization
 Additional Examinations

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<td>T-MATH-113364</td>
<td>Curves on Surfaces</td>
<td>3 CR</td>
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</table>

Competence Certificate
The module will be completed by an oral exam (of ca. 20 - 30 min).

Prerequisites
None

Competence Goal
At the end of the course, students

- have a deeper understanding of the topology and geometry of surfaces, as well as of the structure of their homeomorphisms;
- are able to work independently and critically;
- are prepared to read recent research articles and work on a thesis on mapping class groups and related topics.

Content

- curves on surfaces up to homotopy and isotopy,
- mapping class groups of surfaces,
- Nielsen-Thurston classification of homeomorphisms of surfaces,
- Teichmüller space.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 90 hours
Attendance: 30 hours

- lectures and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendation
The contents of the courses 'Introduction into Geometry and Topology' and 'Elementary Geometry' are recommended. The courses 'Hyperbolic Geometry' and 'Algebraic Topology' can facilitate a deeper understanding of the course contents.
Module: Decision and Game Theory [M-WIWI-102970]

**Responsible:** Prof. Dr. Clemens Puppe

**Organisation:** KIT Department of Economics and Management

**Part of:** Complementary Field / Subject Economics

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**Wahlpflichtangebot (Elective: 9 credits)**

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<td>Auction Theory</td>
<td>4,5 CR</td>
<td>Ehrhart</td>
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<tr>
<td>T-WIWI-102614</td>
<td>Experimental Economics</td>
<td>4,5 CR</td>
<td>Weinhardt</td>
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<tr>
<td>T-WIWI-102861</td>
<td>Advanced Game Theory</td>
<td>4,5 CR</td>
<td>Ehrhart, Puppe, Reiß</td>
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</tbody>
</table>

**Competence Certificate**

The assessment is carried out as partial exams (according to Section 4(2), 1 or 2 of the examination regulation) of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module. The assessment procedures are described for each course of the module separately.

The overall grade of the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

**Prerequisites**

None

**Competence Goal**

The student learns the basics of individual and strategic decisions on an advanced and formal level.

He learns to analyze economic problems through abstract and method-based thinking and to design solution strategies. In the tutorials, the concepts and results of the lecture will be applied in case studies.

**Content**

See German version.

**Workload**

The total workload for this module is approximately 270 hours. For further information see German version.
Module: Designtheory with Applications in Statistics [M-MATH-103087]

**Responsible:** Dr. rer. nat. Bruno Ebner

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

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Ebner, Folkers
### 3.42 Module: Differential Geometry [M-MATH-101317]

**Responsible:** Prof. Dr. Wilderich Tuschmann  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Complementary Field / Field Algebra and Geometry  
- Mathematical Specialization  
- Additional Examinations

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<td>T-MATH-102275</td>
<td>Differential Geometry</td>
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**Prerequisites**  
None
Module: Digital Signatures [M-INFO-100743]

Responsible: Prof. Dr. Dennis Hofheinz
Organisation: KIT Department of Informatics
Part of: Complementary Field / Subject Computer Science

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Mandatory

| T-INFO-101280 | Digital Signatures | 3 CR | Hofheinz |

Competence Goal
The student
- knows important signature schemes that are relevant in theory and practice (such as DSA and tree-based signatures),
- understands basic security notions and their relation (such as existential unforgeability under chosen-message attacks),
- is able to understand and apply basic proof techniques (such as reductions and hybrid arguments)

Content
Digital signatures are a fundamental primitive of modern cryptography. Their practical applications include, for instance, authenticated e-mail or certificate hierarchies on the internet.
This lecture will give an overview of important signature schemes with theoretical or practical relevance. This includes:
- One-time signatures, tree-based signatures, and chameleon hash functions
- RSA-based signatures
- Signatures in bilinear groups
Goal of this lecture is not only to describe these schemes, but also to discuss their security. Therefore we will introduce various security notions for digital signatures, and analyze whether the presented schemes provably meet these notions (under certain hardness assumptions).
Depending on the student's preferences, the remaining time will be used to discuss advanced topics, such as:
- Schnorr signatures
- Programmable hash functions
- Tightness of reductions
- Analysis of hardness assumptions in the generic group model

Workload
90 h
Module: Digital Technology [M-ETIT-102102]

**Responsible:** Prof. Dr.-Ing. Jürgen Becker

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** Complementary Field / Subject Electrical Engineering

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</table>

**Mandatory**

| T-ETIT-101918 | Digital Technology | 6 CR | Becker |

**Competence Certificate**
The examination takes place in form of a written examination lasting 120 minutes.

**Prerequisites**

none

**Competence Goal**
Students will be able to name the basic methods of digital technology and digital information processing with a focus on digital circuits. They are able to apply and analyze coding to digital information. In addition, students know the mathematical basics and can apply graphical and algebraic methods for the design, analysis and optimization of digital circuits and automata.

**Content**
This lecture is an introduction to important theoretical principles of digital technology, which is intended for students of the 1st semester of electrical engineering. Since it therefore cannot build on knowledge of circuit technology, the focus is on abstract modeling of behavior and structures. In addition, the lecture is also intended to teach the basics that are required in other lectures.

The lecture focuses on the formal, methodological and mathematical foundations for designing digital systems. Building on this, the technical realization of digital systems will be discussed, in particular the design and use of standard modules.

**Module grade calculation**
The module grade is the grade of the written examination.

**Workload**
1. attendance time in 23 lectures and 7 exercises: 45 h
2. preparation/follow-up: 90 h. (~2 h per unit)
3. preparation of and attendance in examination: 30 + 2 h

Total: 167 h = 6 LP
### 3.45 Module: Discrete Dynamical Systems [M-MATH-105432]

**Responsible:** PD Dr. Gerd Herzog  
**Organisation:** KIT Department of Mathematics  
**Part of:** Mathematical Methods 1 / Field Analysis  
Mathematical Methods 2 / Field Analysis  
Complementary Field / Field Analysis  
Mathematical Specialization  
Additional Examinations

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<td>German</td>
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</table>

**Mandatory**

| T-MATH-110952 | Discrete Dynamical Systems | 3 CR | Herzog |

**Competence Certificate**
The module will be completed by an oral exam (about 20 min).

**Prerequisites**
None

**Competence Goal**
At the end of the course, students can

- name, discuss and apply fundamental statements of the theory of discrete dynamic systems,
- explain the meaning of dynamic systems using examples,
- describe and use specific techniques of topological dynamics.

**Content**

1. Discrete dynamical systems  
2. Chaotic dynamical systems  
3. Non-expansive mappings  
4. The Fürstenberg-Weiss theorem  
5. Cellular automata  
6. (Weakly) mixing dynamical systems  
7. Dynamics of linear operators

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 90 hours  
Attendance: 30 hours

- lectures, problem classes, and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research relating to the course content,  
- preparation for the module examination

**Recommendation**
Basics of complex analysis (e.g. from Analysis 4) and functional analysis are recommended.
Module: Discrete Time Finance [M-MATH-102919]

**Responsible:** Prof. Dr. Nicole Bäuerle

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

| T-MATH-105839 | Discrete Time Finance | 8 CR | Bäuerle, Fasen-Hartmann, Trabs |

**Competence Certificate**
Written exam of 2h.

**Prerequisites**
none

**Competence Goal**
Students are able to
- understand, describe and use fundamental notions and techniques of modern discrete time finance,
- use specific probabilistic techniques,
- analyze mathematically economical questions in discrete option pricing and optimization,
- work self-organized and in a reflective manner.

**Content**
- Finite financial markets
- The Cox-Ross-Rubinstein-model
- Limit to Black-Scholes
- Characterizing no-arbitrage
- Characterizing completeness
- Incomplete markets
- American options
- Exotic options
- Portfolio optimization
- Preferences and stochastic dominance
- Mean-Variance portfolios
- Risk measures

**Module grade calculation**
The grade of the module is the grade of the written exam.

**Workload**
Total workload: 240 hours

Attendance: 90 h
- lectures and examination

Self studies: 150 h
- follow-up and deepening of the course content,
- literature study and internet research on the course content,
- preparation for the module examination
Recommendation
The content of the module „Probability theory“ is strongly recommended.
Module: Dispersive Equations [M-MATH-104425]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Analysis
            Mathematical Methods 2 / Field Analysis
            Complementary Field / Field Analysis
            Mathematical Specialization
            Additional Examinations

Credits  Grading scale  Recurrence  Duration  Level  Version
6           6 CR

Mandatory

T-MATH-109001 Dispersive Equations

Competence Certificate
The module will be completed by an oral exam (ca. 20 min).

Prerequisites
None

Competence Goal
Graduates will be able to
- recognize the essential properties of dispersive partial differential equations and explain them using examples.
- name the particular difficulties of dispersive equations.
- use techniques to describe the short- and long-term behavior of solutions using the nonlinear Schrödinger equation as an example.
- analyze the stability of solitary waves.
- understand the concept of conservation variables and explain them for specific examples.

Content
- Strichartz estimates, Sobolev embeddings and conservation laws
- Well-posedness results
- Long-term behavior of solutions (virial and Morawetz identities)
- orbital stability of solitary waves (variational description and concentration compactness)
- Energy conservation (invariant transmission coefficients)

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 hours
Attendance: 60 hours
  - lectures, problem classes, and examination
Self-studies: 120 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

Recommendation
The contents of the course ‘Functional Analysis’ are recommended.
### 3.48 Module: Distributed Discrete Event Systems [M-ETIT-100361]

**Responsible:** Prof. Dr.-Ing. Michael Heizmann  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Complementary Field / Subject Electrical Engineering

<table>
<thead>
<tr>
<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
<th>Level</th>
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<td>4</td>
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<td>Each summer term</td>
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<table>
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<tbody>
<tr>
<td>T-ETIT-100960</td>
<td>Distributed Discrete Event Systems</td>
</tr>
</tbody>
</table>

**Prerequisites**
none
### 3.49 Module: Dynamical Systems [M-MATH-103080]

**Responsible:** Prof. Dr. Wolfgang Reichel  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 2 / Field Analysis  
- Complementary Field / Field Analysis  
- Mathematical Specialization  
- Additional Examinations

<table>
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<tr>
<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
<th>Level</th>
<th>Version</th>
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<tr>
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**Mandatory**

<table>
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<th>Course</th>
<th>Lecturer</th>
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</thead>
<tbody>
<tr>
<td>8</td>
<td>Dynamical Systems</td>
<td>Reichel</td>
</tr>
</tbody>
</table>

**Competence Certificate**  
The module will be completed by an oral exam (ca. 30 min).

**Prerequisites**  
none

**Competence Goal**  
Graduates will be able to

- explain the significance of dynamical systems using examples,
- relate the concepts of a discrete-time and continuous-time dynamical system to each other,
- describe important methods for analyzing dynamical systems and use them to analyze the asymptotic behavior of solutions near equilibria for different dynamical systems,
- describe the behavior of invariant sets under discretization.

**Content**

- Examples of finite- and infinite-dimensional dynamical systems  
- Fixed points, periodic orbits, limit sets  
- Invariant sets  
- Attractors  
- Upper and lower continuity of attractors  
- Stable and unstable manifolds  
- Center manifolds

**Module grade calculation**  
The module grade is the grade of the oral exam.

**Workload**  
Total workload: 240 hours  
Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research relating to the course content,  
- preparation for the module examination

**Recommendation**  
The module 'Functional Analysis' is recommended.
### 3.50 Module: Economic Theory and its Application in Finance [M-WIWI-101502]

**Responsible:** Prof. Dr. Kay Mitusch  
**Organisation:** KIT Department of Economics and Management  
**Part of:** Complementary Field / Subject Economics

<table>
<thead>
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<th>Credits</th>
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<th>Recurrence</th>
<th>Duration</th>
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<th>Level</th>
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<td>Each term</td>
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**Compulsory Elective Courses (Election: 1 item)**

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Lecturer(s)</th>
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<tbody>
<tr>
<td>T-WIWI-102609</td>
<td>Advanced Topics in Economic Theory</td>
<td>4.5 CR</td>
<td>Mitusch</td>
</tr>
<tr>
<td>T-WIWI-102861</td>
<td>Advanced Game Theory</td>
<td>4.5 CR</td>
<td>Ehrhart, Puppe, Reiß</td>
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**Supplementary Courses (Election: )**

<table>
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<tbody>
<tr>
<td>T-WIWI-113469</td>
<td>Advanced Corporate Finance</td>
<td>4.5 CR</td>
<td>Ruckes</td>
</tr>
<tr>
<td>T-WIWI-102647</td>
<td>Asset Pricing</td>
<td>4.5 CR</td>
<td>Ruckes, Uhrig-Homburg</td>
</tr>
<tr>
<td>T-WIWI-109050</td>
<td>Corporate Risk Management</td>
<td>4.5 CR</td>
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<tr>
<td>T-WIWI-102623</td>
<td>Financial Intermediation</td>
<td>4.5 CR</td>
<td>Ruckes</td>
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</table>

**Competence Certificate**

The assessment is carried out as partial exams (according to Section 4(2), 1 or 2 of the examination regulation) of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module. The exams are offered at the beginning of the recess period about the subject matter of the latest held lecture. Re-examinations are offered at every ordinary examination date. The assessment procedures are described for each course of the module separately. The overall grade for the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

**Prerequisites**

One of the courses T-WIWI-102861 "Advanced Game Theory" and T-WIWI-102609 "Advanced Topics in Economic Theory" is compulsory.

**Competence Goal**

The students

- have learnt the methods of formal economic modeling, particularly of General Equilibrium Theory and contract theory
- will be able to apply these methods to the topics in Finance, specifically the areas of financial markets and institutions and corporate finance
- have gained many useful insights into the relationship between firms and investors and the functioning of financial markets

**Content**

The mandatory course "Advanced Topics in Economic Theory" is devoted in equal parts to General Equilibrium Theory and to contract theory. The course "Asset Pricing" will apply techniques of General Equilibrium Theory to valuation of financial assets. The courses "Corporate Financial Policy" and "Finanzintermediation" will apply the techniques of contract theory to issues of corporate finance and financial institutions.

**Workload**

Total workload for 9 credit points: approx. 270 hours  
The exact distribution is based on the credit points of the courses in the module.
3.51 Module: Eigenvalue Problems in Complicated Domains [M-MATH-103262]

**Responsible:** Dr. Andrii Khrabustovskyi

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

<table>
<thead>
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<th>Credits</th>
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<th>Duration</th>
<th>Level</th>
<th>Version</th>
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<td>Grade to a tenth</td>
<td>Once</td>
<td>1 term</td>
<td>4</td>
<td>1</td>
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</table>

**Mandatory**

| T-MATH-106497 | Eigenvalue Problems in Complicated Domains | 4 CR | Khrabustovskyi |

**Prerequisites**

none

**Competence Goal**

At the end of the course the students will know several methods of perturbation theory and spectral theory. They will be able to apply these methods to various eigenvalue problems in complicated domains. They will know several associated concepts: capacity, strong/weak connectivity etc.

**Content**

In the first part of the course we treat some abstract topics: various types of resolvent convergence and their properties, spectral convergence, convergence in varying Hilbert spaces, min-max principle and its applications.

Then, in the second part, we apply these methods to the main object of our interest – eigenvalue problems in domains with complicated geometry. The following topics will be treated:

- Eigenvalue problems in varying domains: general results.
- Laplace operator in a domain with a hole. Capacity.
- Homogenization in perforated domains.
Competence Certificate
Success control is carried out in the form of a written test of 120 minutes.

Prerequisites
none

Competence Goal
Students with very different background in electromagnetic field theory will be brought to a high level of comprehension. They will understand the concept of electric & magnetic fields and of electric potential & vector potential and they will be able to solve simple problems of electric & magnetic fields using mathematics. They will understand the equations and solutions of wave creation and wave propagation. Finally the student will have learnt the basics of numerical field calculation and be able to use software packages of numerical field calculation in a comprehensive and critical way.

The student will

- be able to deal with all quantities of electromagnetic field theory (E, D, B, H, J, M, P, ...), in particular: how to calculate and how to measure them,
- derive various equations from the Maxwell equations to solve simple field problems (electrostatics, magnetostatics, steady currents, electromagnetics),
- be able to deal with the concept of field energy density and solve practical problems using it (coefficients of capacitance and coefficients of inductance),
- be able to derive and use the wave equation, in particular: to solve problems how to create a wave and calculate solutions of wave propagation through various media,
- be able to outline the concepts, the main application areas and the limitations of methods of numerical field calculation (FDM, FDTD, FIM, FEM, BEM, MoM, TLM)
- be able to use one exemplary software package of numerical field calculation and solve simple practical problems with it.
Content
This course first gives a comprehensive recap of Maxwell equations and important equations of electromagnetic field theory. In the second part the most important methods of numerical field calculation are introduced.

Maxwell’s equations, materials equations, boundary conditions, fields in ferroelectric and ferromagnetic materials
electric potentials, electric dipole, Coulomb integral, Laplace and Poisson’s equation, separation of variables in cartesian, cylindrical and spherical coordinates

Dirichlet Problem, Neumann Problem, Greens function, Field energy density and Poynting vector,
electrostatic field energy, coefficients of capacitance, vector potential, Coulomb gauge, Biot-Savart-law, magnetic field energy, coefficients of inductance magnetic flux and coefficients of mutual inductance, field problems in steady electric currents,
law of induction, displacement current
general wave equation for E and H, Helmholtz equation
skin effect, penetration depth, eddy currents
retarded potentials, Coulomb integral with retarded potentials
wave equation for potential and Vector potential and A, Lorentz gauge, plane waves
Hertzian dipole, near field solution, far field solution
transmission lines, fields in coaxial transmission lines
waveguides, TM-waves, TE-waves
finite difference method FDM
finite difference - time domain FDTD, Yee’s algorithm
finite difference - frequency domain
finite integration method FIM
finite element method FEM
boundary element method BEM, Method of Moments (MOM), Transmission Line Matrix Methal (TLM),
solving large systems of linear equations
basic rules for good numerical field calculation

The lecturer reserves the right to alter the contents of the course without prior notification.

Module grade calculation
The module grade is the grade of the written exam.

Workload
Each credit point corresponds to approximately 25-30 hours of work (of the student). This is based on the average student who achieves an average performance. The workload includes:

Attendance time in lectures (3 h 15 appointments each) = 45 h
Self-study (4 h 15 appointments each) = 60 h
Preparation / post-processing = 20 h
Total effort approx. 125 hours = 4 LP

Recommendation
Fundamentals of electromagnetic field theory.

Literature
Matthew Sadiku (2001), Numerical Techniques in Electromagnetics.
CRC Press, Boca Raton, 0-8493-1395-3
Artech House, Boston, 1-58053-076-1
Springer Verlag, New York, 0-387-94877-5
IOS Press, Ohmsha, 1 58603 064 7
### Module: Energy Economics and Technology [M-WIWI-101452]

**Responsible:** Prof. Dr. Wolf Fichtner  
**Organisation:** KIT Department of Economics and Management  
**Part of:** Complementary Field / Subject Economics

<table>
<thead>
<tr>
<th>Credits</th>
<th>Grade to a tenth</th>
<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
<th>Level</th>
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<tbody>
<tr>
<td>9</td>
<td></td>
<td>Each term</td>
<td>1 term</td>
<td>German/English</td>
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#### Compulsory Elective Courses (Election: at least 9 credits)

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<th>Code</th>
<th>Title</th>
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<th>Instructor</th>
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<tbody>
<tr>
<td>T-WIWI-102793</td>
<td>Efficient Energy Systems and Electric Mobility</td>
<td>3,5</td>
<td>Jochem</td>
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<tr>
<td>T-WIWI-102650</td>
<td>Energy and Environment</td>
<td>3,5</td>
<td>Karl</td>
</tr>
<tr>
<td>T-WIWI-113073</td>
<td>Machine Learning and Optimization in Energy Systems</td>
<td>4</td>
<td>Fichtner</td>
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<tr>
<td>T-WIWI-107464</td>
<td>Smart Energy Infrastructure</td>
<td>5,5</td>
<td>Ardone, Pustisek</td>
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<tr>
<td>T-WIWI-102695</td>
<td>Heat Economy</td>
<td>3,5</td>
<td>Fichtner</td>
</tr>
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</table>

#### Competence Certificate

The assessment is carried out as partial written exams (according to Section 4(2), 1 of the examination regulation) of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module. The examinations take place every semester. Re-examinations are offered at every ordinary examination date. The assessment procedures are described for each course of the module separately.

The overall grade of the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

#### Prerequisites

None

#### Competence Goal

The student

- gains detailed knowledge about present and future energy supply technologies (focus on final energy carriers electricity and heat),
- knows the techno-economic characteristics of plants for energy provision, for energy transport as well as for energy distribution and demand,
- is able to assess the environmental impact of these technologies.

#### Content

- **Heat Economy:** district heating, heating technologies, reduction of heat demand, statutory provisions
- **Energy Systems Analysis:** Interdependencies in energy economics, energy systems modelling approaches in energy economics
- **Energy and Environment:** emission factors, emission reduction measures, environmental impact
- **Efficient Energy Systems and Electric Mobility:** concepts and current trends in energy efficiency, Overview of and economical, ecological and social impacts through electric mobility

#### Workload

The total workload for this module is approx. 270 hours (9 credits). The allocation is based on the credit points of the courses in the module. The workload for courses with 3,5 credits is approx. 105 hours, and for courses with 5,5 credits approx. 165 hours.

The total number of hours per course is calculated from the time required to attend the lectures and exercises, as well as the examination times and the time required for an average student to achieve the learning objectives of the module for an average performance.
Module: Ergodic Theory [M-MATH-106473]

**Responsible:** Dr. Gabriele Link  
**Organisation:** KIT Department of Mathematics

**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 1 / Field Stochastics  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Stochastics  
- Complementary Field / Field Algebra and Geometry  
- Complementary Field / Field Stochastics  
- Mathematical Specialization  
- Additional Examinations

**Credits:** 8  
**Grading scale:** Grade to a tenth  
**Recurrence:** Irregular  
**Duration:** 1 term  
**Language:** German  
**Level:** 4  
**Version:** 1

<table>
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<tbody>
<tr>
<td>T-MATH-113086 Ergodic Theory</td>
</tr>
</tbody>
</table>

**Competence Certificate**  
Oral examination of ca. 20-30 minutes.

**Prerequisites**  
None

**Competence Goal**  
Students  
- know important examples of dynamical systems,  
- can state and discuss substantial concepts of ergodic theory,  
- can state important results on qualitative properties of dynamical systems and relate them,  
- are prepared to read recent research articles and write a bachelor or master thesis in the field of ergodic theory.

**Content**  
- Elementary examples of dynamical systems such as Bernoulli systems and billiards  
- Poincare rekurrence and ergodic theorems  
- mixing, weak mixing, equidistribution  
- entropy  
- advanced topic(s) (as for example hyperbolic dynamics, symbolic dynamics and coding, Furstenberg correspondence principle or unitary representations of SL(2,R))

**Module grade calculation**  
The grade of the module is the grade of the oral exam.

**Workload**  
Total workload: 240 hours  
Attendance: 90 h  
- lectures, problem classes and examination  
Self studies: 150 h  
- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research on the course content,  
- preparation for the module examination

**Recommendation**  
Some basic knowledge of measure theory, topology, geometry, group theory and functional analysis is recommended.
3.55 Module: Evolution Equations [M-MATH-102872]

**Responsible:** Prof. Dr. Roland Schnaubelt

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

**Credits:** 8

**Grading scale:** Grade to a tenth

**Recurrence:** see Annotations

**Duration:** 1 term

**Language:** German/English

**Level:** 4

**Version:** 1

<table>
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<th>Course Title</th>
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<tr>
<td>T-MATH-105844</td>
<td>8 CR</td>
<td>Evolution Equations</td>
<td></td>
<td>Frey, Kunstmann, Schnaubelt</td>
</tr>
</tbody>
</table>

**Competence Certificate**

Oral examination of ca. 30 minutes.

**Prerequisites**

none

**Competence Goal**

The students

- can explain the basics of the theory of strongly continuous operator semigroups and their generators, in particular the theorems on generation and wellposedness, and they can apply it to examples.
- can also describe and use the solution and regularity theory of inhomogeneous Cauchy problems.
- are able to construct analytic semigroups and to characterize their generators. Using these results and perturbations theorems, they can solve partial differential equations.
- are able to explain main aspects of approximation theory of evolution equations.
- can discuss the core statements of stability and spectral theory of operator semigroups and discuss examples by means of them.
- have mastered the important techniques for proofs in evolution equations and are able to, at least, sketch the complicated proofs.

**Content**

- strongly continuous operator semigroups and their generators,
- generation results and wellposedness,
- inhomogeneous Cauchy problems,
- analytic semigroups,
- perturbation and approximation theory,
- stability and spectral theory of operator semigroups,
- applications to partial differential equations

**Module grade calculation**

The grade of the module is the grade of the oral exam.

**Annotation**

Regular cycle: every 2nd year. The module "Nonlinear Evolution Equations" is based on "Evolution Equations"
Workload
Total workload: 240 hours
Attendance: 90 h
  • lectures, problem classes and examination
Self studies: 150 h
  • follow-up and deepening of the course content,
  • work on problem sheets,
  • literature study and internet research on the course content,
  • preparation for the module examination

Recommendation
The module “Functional Analysis” is strongly recommended.

Literature
K.-J. Engel und R. Nagel, One-Parameter Semigroups for Linear Evolution Equations.
Module: Exponential Integrators [M-MATH-103700]

Responsible: Prof. Dr. Marlis Hochbruck
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

Credits 6
Grading scale Grade to a tenth
Recurrence Irregular
Duration 1 term
Level 4
Version 1

M Mandatory
T-MATH-107475 Exponential Integrators

Competence Certificate
Oral exam of approximately 20 minutes.

Prerequisites
None.

Competence Goal
Graduates will be able to name key concepts for the construction and analysis of exponential integrators and implement them efficiently.

Content
In this class we consider the construction, analysis, implementation and application of exponential integrators. The focus will be on two types of stiff problems.

The first one is characterized by a Jacobian that possesses eigenvalues with large negative real parts. Parabolic partial differential equations and their spatial discretization are typical examples. The second class consists of highly oscillatory problems with purely imaginary eigenvalues of large modulus.

Apart from motivating the construction of exponential integrators for various classes of problems, our main intention in this class is to present the mathematics behind these methods. We will derive error bounds that are independent of stiffness or highest frequencies in the system.

Since the implementation of exponential integrators requires the evaluation of the product of a matrix function with a vector, we will briefly discuss some possible approaches as well.

Module grade calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 180 h

Attendance: 60 h
  • Course including module examination during study.

Self-studies: 120 h
  • Deepening the study content by working on the lecture content at home
  • Working on exercises
  • In-depth study of the course content using suitable literature and Internet research,
  • preparation for the module examination during study.

Recommendation
Basic knowledge of ordinary and/or partial differential equations as well as the contents of the module "Numerical Methods for Differential Equations" are strongly recommended. Knowledge of functional analysis is also recommended.
3.57 Module: Extremal Graph Theory [M-MATH-102957]

**Responsible:** Prof. Dr. Maria Aksenovich

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Algebra and Geometry
- Complementary Field / Field Algebra and Geometry
- Mathematical Specialization
- Additional Examinations

<table>
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<th>Credits</th>
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<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
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<tr>
<td>T-MATH-105931</td>
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</table>

**Competence Certificate**
The final grade is given based on an oral exam (approx. 30 min.).

**Competence Goal**
The students understand, describe, and use fundamental notions and techniques in extremal graph theory. They can analyze, structure, and formally describe typical combinatorial questions. The students understand and use Szemeredi’s regularity lemma and Szemeredi’s theorem, can use probabilistic techniques, such as dependent random choice and multistep random colorings, know the best bounds for the extremal numbers of complete graphs, cycles, complete bipartite graphs, and bipartite graphs with bounded maximum degree. They understand and can use the Ramsey theorem for graphs and hypergraphs, as well as stepping-up techniques for bounding Ramsey numbers. Moreover, the students know and understand the behavior of Ramsey numbers for graphs with bounded maximum degree. The students can communicate using English technical terminology.

**Content**
The course is concerned with advanced topics in graph theory. It focuses on the areas of extremal functions, regularity, and Ramsey theory for graphs and hypergraphs. Further topics include Turán's theorem, Erdös-Stone theorem, Szemerédi's lemma, graph colorings and probabilistic techniques.

**Annotation**
Course is held in English

**Recommendation**
Basic knowledge of linear algebra, analysis and graph theory is recommended.
3.58 Module: Extreme Value Theory [M-MATH-102939]

Responsible: Prof. Dr. Vicky Fasen-Hartmann
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Stochastics
Mathematical Methods 2 / Field Stochastics
Complementary Field / Field Stochastics
Mathematical Specialization
Additional Examinations

Credits: 4
Grading scale: Grade to a tenth
Recurrence: Irregular
Duration: 1 term
Level: 4
Version: 2

Mandatory

| T-MATH-105908 | Extreme Value Theory | 4 CR | Fasen-Hartmann |

Competence Certificate
The module will be completed by an oral exam (approx. 20 min).

Prerequisites
None

Competence Goal
Students are able to
- name, explain, motivate and apply statistical methods for estimating risk measures,
- model and quantify extreme events,
- apply specific probabilistic techniques of extreme value theory,
  - master proof techniques,
- work in a self-organised and reflective manner.

Content
- Theorem of Fisher and Tippett's
- Generalised extreme value and Pareto distribution (GED and GPD)
- Domain of attractions of generalised extreme value distributions
- Theorem of Pickands-Balkema-de Haan
- Estimation of risk measures
- Hill estimator
- Block maxima method
- POT method

Module grade calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 120 hours
Attendance: 45 hours
- lectures and problem classes including the examination.

Self studies: 75 hours
- follow-up and deepening of the course content
- work on problem sheets
- literature and internet research on the course content
- preparation for the module examination
Recommendation
The content of the module "Probability theory" is recommended.
### Module: Finance 1 [M-WIWI-101482]

**Responsible:**
- Prof. Dr. Martin Ruckes
- Prof. Dr. Marliese Uhrig-Homburg

**Organisation:** KIT Department of Economics and Management

**Part of:** Complementary Field / Subject Economics

<table>
<thead>
<tr>
<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
<th>Level</th>
<th>Version</th>
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<td>9</td>
<td>Grade to a tenth</td>
<td>Each term</td>
<td>1 term</td>
<td>German/English</td>
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**Compulsory Elective Courses (Electing: 9 credits)**

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<th>Course Title</th>
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<tr>
<td>T-WIWI-102643</td>
<td>Derivatives</td>
<td>4.5 CR</td>
<td>Uhrig-Homburg</td>
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<tr>
<td>T-WIWI-102621</td>
<td>Valuation</td>
<td>4.5 CR</td>
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<tr>
<td>T-WIWI-102647</td>
<td>Asset Pricing</td>
<td>4.5 CR</td>
<td>Ruckes, Uhrig-Homburg</td>
</tr>
</tbody>
</table>

**Competence Certificate**

The assessment is carried out as partial exams (according to Section 4(2), 1 or 2 of the examination regulation) of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module. The assessment procedures are described for each course of the module separately.

The overall grade of the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

**Prerequisites**

None

**Competence Goal**

The student

- has core skills in economics and methodology in the field of finance
- assesses corporate investment projects from a financial perspective
- is able to make appropriate investment decisions on financial markets

**Content**

The courses of this module equip the students with core skills in economics and methodology in the field of modern finance. Securities which are traded on financial and derivative markets are presented, and frequently applied trading strategies are discussed. A further focus of this module is on the assessment of both profits and risks in security portfolios and corporate investment projects from a financial perspective.

**Workload**

The total workload for this module is approx. 270 hours (9 credits). The distribution is based on the credit points of the courses in the module. The workload for courses with 4.5 credits is approx. 135 hours.

The total number of hours per course is calculated from the time required to attend the lectures and exercises, as well as the examination times and the time required for an average student to achieve the learning objectives of the module for an average performance.
Module: Finance 2 [M-WIWI-101483]

**3.60 Module: Finance 2 [M-WIWI-101483]**

**Responsible:** Prof. Dr. Martin Ruckes  
Prof. Dr. Marliese Uhrig-Homburg

**Organisation:** KIT Department of Economics and Management

**Part of:** Complementary Field / Subject Economics

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**Election notes**

This module will not count towards the degree until the module Finance 1 has also been successfully completed. If the module Finance 1 is booked out to the additional examinations, the Finance 2 module loses its curricular validity/valuation for the degree.

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**Compulsory Elective Courses (Election: at least 9 credits)**

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<tbody>
<tr>
<td>4,5</td>
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**Competence Certificate**

The assessment is carried out as partial exams (according to Section 4(2), 1 or 2 of the examination regulation) of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module. The assessment procedures are described for each course of the module separately. The overall grade of the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

**Prerequisites**

It is only possible to choose this module in combination with the module Finance 1. The module is passed only after the final partial exam of Finance 1 is additionally passed.

**Modeled Conditions**

The following conditions have to be fulfilled:

1. The module M-WIWI-101482 - Finance 1 must have been started.

**Competence Goal**

The student is in a position to discuss, analyze and provide answers to advanced economic and methodological issues in the field of modern finance.
**Content**
The module Finance 2 is based on the module Finance 1. The courses of this module equip the students with advanced skills in economics and methodology in the field of modern finance on a broad basis.

**Annotation**
The courses *eFinance: Information Engineering and Management for Securities Trading* [2540454] and *Financial Analysis* [2530205] can be chosen from summer term 2015 on.

**Workload**
The total workload for this module is approximately 270 hours. For further information see German version.
### 3.61 Module: Finance 3 [M-WIWI-101480]

**Responsible:** Prof. Dr. Martin Ruckes  
Prof. Dr. Marliese Uhrig-Homburg

**Organisation:** KIT Department of Economics and Management  
Part of: Complementary Field / Subject Economics

**Credits:** 9  
**Grading scale:** Grade to a tenth  
**Recurrence:** Each term  
**Duration:** 1 term  
**Language:** German/English  
**Level:** 4  
**Version:** 9

**Election notes**

This module will not count towards the degree until the modules Finance 1 and Finance 2 have also been successfully completed. If the modules Finance 1 and/or Finance 2 are booked out to the additional examinations, the Finance 3 module loses its curricular validity/valuation for the degree.

**Compulsory Elective Courses (Election: at least 9 credits)**

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<td>Web App Programming for Finance</td>
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**Competence Certificate**

The assessment is carried out as partial exams (according to Section 4(2), 1 or 2 of the examination regulation) of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module. The assessment procedures are described for each course of the module separately.

The overall grade of the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

**Prerequisites**

It is only possible to choose this module in combination with the module Finance 1 and Finance 2. The module is passed only after the final partial exams of Finance 1 and Finance 2 are additionally passed.

**Modeled Conditions**

The following conditions have to be fulfilled:

1. The module M-WIWI-101482 - Finance 1 must have been started.
2. The module M-WIWI-101483 - Finance 2 must have been started.

**Competence Goal**

The student is in a position to discuss, analyze and provide answers to advanced economic and methodological issues in the field of modern finance.
Content
The courses of this module equip the students with advanced skills in economics and methodology in the field of modern finance on a broad basis.

Workload
The total workload for this module is approximately 270 hours. For further information see German version.
## 3.62 Module: Finite Element Methods [M-MATH-102891]

<table>
<thead>
<tr>
<th>Responsible:</th>
<th>Prof. Dr. Willy Dörfler</th>
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<tr>
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<td>Prof. Dr. Christian Wieners</td>
</tr>
<tr>
<td>Organisation:</td>
<td>KIT Department of Mathematics</td>
</tr>
<tr>
<td>Part of:</td>
<td>Mathematical Methods 1 / Field Applied and Numerical Mathematics</td>
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<td>Each winter term</td>
<td>1 term</td>
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<th>8 CR</th>
<th>Dörfler, Hochbruck, Jahnke, Maier, Rieder, Wieners</th>
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</thead>
</table>
Module: Forecasting: Theory and Practice [M-MATH-102956]

**Responsible:** Prof. Dr. Tilmann Gneiting

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

**Credits:** 8

**Grading scale:** Grade to a tenth

**Recurrence:** Irregular

**Duration:** 2 terms

**Language:** English

**Level:** 4

**Version:** 2

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<td>8 CR</td>
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**Prerequisites**
None

**Annotation**
- Regular cycle: every 2nd year, starting winter semester 16/17
- Course is held in English
### Module: Formal Systems [M-INFO-100799]

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<tr>
<td>T-INFO-101336</td>
<td>Formal Systems</td>
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</table>
# 3.65 Module: Foundations of Continuum Mechanics [M-MATH-103527]

**Responsible:** Prof. Dr. Christian Wieners  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
- Additional Examinations  

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<td>Foundations of Continuum Mechanics</td>
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**Prerequisites**

none
Module: Fourier Analysis and its Applications to PDEs [M-MATH-104827]

**Responsible:** TT-Prof. Dr. Xian Liao

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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<td>T-MATH-109850</td>
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</table>

**Prerequisites**
None
Module: Fractal Geometry [M-MATH-105649]

Responsible: PD Dr. Steffen Winter
Organisation: KIT Department of Mathematics
Part of:
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Algebra and Geometry
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

 Credits: 6
Grading scale: Grade to a tenth
Recurrence: Irregular
Duration: 1 term
Language: German/English
Level: 4
Version: 2

Mandatory

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Competence Certificate
The module will be completed with an oral exam (20 - 30 min).

Prerequisites
None

Competence Goal
Students
- can name and explain important terms and concepts of fractal geometry;
- know important results of dimension theory and can apply them to examples;
- have the ability to use specific methods for the analysis of fractal structures;
- are able to construct fractals and random fractals with certain prescribed properties;
- master important proof techniques in fractal geometry and are able to at least sketch the more difficult proofs;
- are able to work self-organized and in a reflective manner;
- are prepared, to write a thesis in the field of fractal geometry.

Content
- iterated function systems and self-similar sets
- chaos game algorithm
- random fractals
- fractal dimension theory
- Hausdorff measure and dimension
- packing measure and dimension
- Minkowski contents
- methods of computing dimension
- self-similar measures and multifractals
- dimension of measures

Module grade calculation
The module grade is the grade of the oral exam.
Workload
Total workload: 180 hours
Attendance: 60 h
• lectures, problem classes and examination
Self studies: 120 h
• follow-up and deepening of the course content,
• work on problem sheets,
• literature study and internet research on the course content,
• preparation for the module examination

Recommendation
The contents of the courses Analysis 3 (measure theory) and Probability theory are recommended.
3.68 Module: Functional Analysis [M-MATH-101320]

**Responsible:** Prof. Dr. Roland Schnaubelt

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

<table>
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<th>Recurrence</th>
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<th>Level</th>
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<td>Each winter term</td>
<td>1 term</td>
<td>4</td>
<td>2</td>
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**Mandatory**

| T-MATH-102255 | Functional Analysis | 8 CR | Frey, Herzog, Hundertmark, Lamm, Liao, Reichel, Schnaubelt, Tolksdorf |

**Competence Certificate**
Written examination of 120 minutes.

**Prerequisites**
None

**Competence Goal**
The students can

- explain basic topological concepts such as compactness in the framework of metric spaces, and are able to apply these in examples.
- describe the structure of Hilbert spaces and can use them in applications.
- explain the principle of uniform boundedness, the open mapping theorem and the Hahn-Banach theorem, and are able to derive conclusions from them.
- describe the concepts of dual Banach spaces, in particular weak convergence, reflexivity and the Banach-Alaoglu theorem. They can discuss these concepts in examples.
- explain the spectral theorem for compact self-adjoint operators.
- come up with a proof for simple functional analytic statements.

**Content**

- Metric spaces (basic topological concepts, compactness),
- Hilbert spaces, Orthonormal bases, Sobolev spaces,
- Continuous linear operators on Banach spaces (principle of uniform boundedness, open mapping theorem),
- Dual spaces and representations, Hahn-Banach theorem, Banach-Alaoglu theorem, weak convergence, reflexivity,
- Spectral theorem for compact self-adjoint operators.

**Module grade calculation**
The grade of the module is the grade of the written exam.

**Workload**
Total workload: 240 hours

- Attendance: 90 h
  - lectures, problem classes and examination

- Self studies: 150 h
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research on the course content,
  - preparation for the module examination
Module: Functional Data Analysis [M-MATH-106485]

Responsible: Dr. rer. nat. Bruno Ebner

Organisation: KIT Department of Mathematics

Part of:
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

Credits: 4
Grading scale: Grade to a tenth
Recurrence: Irregular
Duration: 1 term
Language: English
Level: 4
Version: 2

Mandatory

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<td>Functional Data Analysis</td>
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</table>

Competence Certificate
Oral examination of ca. 25 minutes.

Prerequisites
None

Competence Goal
The aim of the course is to give an introduction to weak convergence concepts in metric spaces and to highlight some statistical applications.

After successful participation students can
- model random elements in metric spaces,
- explain the concept of weak convergence in metric spaces and are familiar with structural problems in this context,
- apply limit laws for functionals of the empirical distribution function,
- model the normal distribution for random elements in Hilbert spaces,
- derive limit distributions of L2 type goodness-of-fit statistics,
- apply goodness-of-fit tests to functional data.

Content
- Theorem of Glivenko-Cantelli,
- weak convergence in metric spaces,
- Theorem of Prokhorov,
- Gaussian Processes,
- Donsker’s Theorem,
- functional central limit theorem,
- empirical processes,
- random elements in separable Hilbert spaces,
- Goodness-of-fit tests.

Module grade calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 120 hours
Attendance: 45 h
- lectures and examination
Self studies: 75 h
- follow-up and deepening of the course content,
- literature study and internet research on the course content,
- preparation for the module examination
**Recommendation**
The contents of the modules "Probability Theory" and "Mathematical Statistics" are strongly recommended.
3.70 Module: Functions of Matrices [M-MATH-102937]

Responsible: PD Dr. Volker Grimm
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
         Mathematical Methods 2 / Field Applied and Numerical Mathematics
         Complementary Field / Field Applied and Numerical Mathematics
         Mathematical Specialization
         Additional Examinations

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</table>

Competence Certificate
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
none

Competence Goal
The students know the basic definitions and properties of matrix functions. They can evaluate methods for approximating matrix functions in terms of convergence and efficiency, independently solve exercises, present their own solutions and implement the methods discussed.

Content
- Definition of functions of matrices
- Approximations to functions of matrices for large sparse matrices
- Krylov subspace methods and rational Krylov subspace methods
- Application to the numerical solution of partial differential equations

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours
Attendance: 90 hours
- lectures, problem classes, and examination

Self-studies: 150 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendation
The courses Numerical Analysis 1 and 2 are strongly recommended.
Module: Functions of Operators [M-MATH-102936]

**Responsible:** PD Dr. Volker Grimm

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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**Competence Certificate**

The module will be completed by an oral exam (ca. 20 min).

**Prerequisites**

None

**Competence Goal**

The students have basic knowledge of the approximation of functions of operators. They can examine the methods for convergence properties and efficiency. In the context of semigroups, they can analyze the procedures discussed, independently select the appropriate procedures and justify their choice.

**Content**

- Definition of functions of operators
- Strongly continuous and analytic semigroups
- Rational approximations to functions of operators with fixed poles
- Rational Krylov subspace method for the approximation of functions of operators
- Applications in the numerical analysis of semigroups

**Module grade calculation**

The module grade is the grade of the oral exam.

**Workload**

Total workload: 180 hours

- **Attendance:** 60 hours
  - lectures, problem classes, and examination

- **Self-studies:** 120 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

**Recommendation**

The courses Numerical Analysis 1 and 2, and Functional Analysis are strongly recommended.
3.72 Module: Fuzzy Sets [M-INFO-100839]

**Responsible:** Prof. Dr.-Ing. Uwe Hanebeck

**Organisation:** KIT Department of Informatics

**Part of:** Complementary Field / Subject Computer Science

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Module: Generalized Regression Models [M-MATH-102906]

**Responsible:** PD Dr. Bernhard Klar

**Organisation:** KIT Department of Mathematics

**Part of:** Mathematical Methods 1 / Field Stochastics
Mathematical Methods 2 / Field Stochastics
Complementary Field / Field Stochastics
Mathematical Specialization
Additional Examinations

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</table>

**Competence Certificate**
The module will be completed by an oral exam (ca. 20 min).

**Prerequisites**
None

**Competence Goal**
At the end of the course, students will

- be familiar with the most important regression models and their properties,
- be able to evaluate and interpret the results obtained using these models,
- be able to use the models to analyze more complex data sets.

**Content**
This course covers basic models of statistics that allow us to capture relationships between variables. Topics include

- Linear regression models:
  - Model diagnostics
  - Multicollinearity
  - Variable selection
  - Generalized least squares
- Nonlinear regression models:
  - Parameter estimation
  - Asymptotic normality of maximum likelihood estimators
- Regression models for count data
- Generalized linear models:
  - Parameter estimation
  - Model diagnostics
  - Overdispersion and quasi-likelihood

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 120 hours

<table>
<thead>
<tr>
<th>Attendance: 45 hours</th>
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<tr>
<td>lectures, problem classes, and examination</td>
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</table>

Self-studies: 75 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination
**Recommendation**
The contents of the course "Statistics" are strongly recommended.
### Module: Geometric Analysis [M-MATH-102923]

**Responsible:** Prof. Dr. Tobias Lamm  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 2 / Field Analysis  
- Complementary Field / Field Analysis  
- Mathematical Specialization  
- Additional Examinations

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**Prerequisites**
none
Module: Geometric Group Theory [M-MATH-102867]

**Responsible:** Prof. Dr. Roman Sauer

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Algebra and Geometry
- Complementary Field / Field Algebra and Geometry
- Mathematical Specialization
- Additional Examinations

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Herrlich, Link, Llosa, Isenrich, Sauer, Tuschmann
3.67 Module: Geometric Group Theory II [M-MATH-102869]

**Responsible:** Prof. Dr. Roman Sauer

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Algebra and Geometry
- Complementary Field / Field Algebra and Geometry
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

| T-MATH-105875 | Geometric Group Theory II | 8 CR | Herrlich, Llosa Isenrich, Sauer |

**Prerequisites**

none
**Module: Geometric Numerical Integration [M-MATH-102921]**

**Responsible:** Prof. Dr. Tobias Jahnke  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
- Additional Examinations

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**Mandatory**

| T-MATH-105919 | Geometric Numerical Integration | 6 CR | Hochbruck, Jahnke |

**Competence Certificate**

The module will be completed by an oral exam (about 20 min).

**Prerequisites**

none

**Competence Goal**

After attending the course, students understand the central properties of finite-dimensional Hamilton systems (energy conservation, symplectic flow, first integrals etc.). They know important classes of geometric time integrators such as, e.g., symplectic (partitioned) Runge-Kutta methods, splitting methods, SHAKE and RATTLE. They are not only able to implement these methods and apply them to practice-oriented problems, but also to analyze and explain the observed long-time behavior (e.g. approximative energy conservation over long times).

**Content**

- Newtonian equation of motion, Lagrange equations, Hamilton systems  
- Properties of Hamilton systems: symplectic flow, energy conservation, other conserved quantities  
- Symplectic numerical methods: symplectic Euler method, Störmer-Verlet method, symplectic (partitioned) Runge-Kutta methods  
- Construction of symplectic methods, for example by composition and splitting  
- Backward error analysis and energy conservation over long time intervals  
- Mechanical systems with constraints

**Module grade calculation**

The module grade is the grade of the oral exam.

**Annotation**

The module is offered about every two years

**Workload**

Total workload: 180 hours  
Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 120 hours

- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research relating to the course content,  
- preparation for the module examination
Recommendation
Familiarity with ordinary differential equations and Runge-Kutta methods (construction, order, stability, etc.) are strongly recommended. The course "Numerical methods for differential equations" provides an excellent basis. Moreover, programming skills in MATLAB are strongly recommended.
Module: Geometric Variational Problems [M-MATH-106667]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Analysis
        Mathematical Methods 2 / Field Analysis
        Complementary Field / Field Analysis
        Mathematical Specialization
        Additional Examinations

<table>
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Mandatory

| T-MATH-113418 | Geometric Variational Problems | 8 CR | Lamm |

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

Competence Goal
The students
• can name basic results in the theory of geometric variational problems and relate them to each other;
• are prepared to write a thesis in the field of geometric analysis.

Content
• Harmonic maps
• Willmore surfaces
• Regularity theory
• Hardy and BMO spaces

Module grade calculation
The module grade is the grade of the oral examination.

Workload
Total workload: 240 hours
Attendance: 90 h
• lectures, problem classes and examination
Self studies: 150 h
• follow-up and deepening of the course content,
• work on problem sheets,
• literature study and internet research on the course content,
• preparation for the module examination

Recommendation
The modules Classical Methods for Partial Differential Equations and Functional Analysis are recommended.
### 3.79 Module: Geometry of Schemes [M-MATH-102866]

**Responsible:** PD Dr. Stefan Kühnlein  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Complementary Field / Field Algebra and Geometry  
- Mathematical Specialization  
- Additional Examinations

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#### Credits

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<td>Geometry of Schemes</td>
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</table>

**Competence Certificate**  
The module is completed by an oral exam of about 30 minutes.

**Prerequisites**  
None

**Competence Goal**  
At the end of the module, participants are able to:

- relate the notion of algebraic schemes with that of algebraic varieties  
- name and discuss basic properties of schemes  
- deal with sheaves on schemes and investigate their properties  
- start to read recent research papers in algebraic geometry and write a thesis in this field.

**Content**

- Sheaves of modules  
- affine schemes  
- varieties and schemes  
- morphisms between schemes  
- coherent and quasicoherent sheaves  
- cohomology of sheaves

**Module grade calculation**  
The grade of the module is the grade of the oral exam.

**Workload**  
Total work load: 240 hours  

- **Attendance:** 90 hours  
  - lectures, problem classes and examination

- **Self studies:** 150 hours  
  - follow-up and deepening of the course content  
  - work on problem sheets  
  - literature studies and internet research relating to the course content  
  - preparation for the module examination

**Recommendation**  
The modules "Algebra" and "Algebraic Geometry" are strongly recommended.
### 3.80 Module: Global Differential Geometry [M-MATH-102912]

**Responsible:** Prof. Dr. Wilderich Tuschmann  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Complementary Field / Field Algebra and Geometry  
- Mathematical Specialization  
- Additional Examinations

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**Prerequisites**  
none
3.81 Module: Graph Theory [M-MATH-101336]

**Responsible:** Prof. Dr. Maria Aksenovich

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Algebra and Geometry
- Complementary Field / Field Algebra and Geometry
- Mathematical Specialization
- Additional Examinations

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<td>Graph Theory</td>
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</table>

**Competence Certificate**

The final grade is given based on the written final exam (3h).

By successfully working on the problem sets, a bonus can be obtained. To obtain the bonus, one has to achieve 50% of the points on the solutions of the exercise sheets 1-6 and also of the exercise sheets 7-12. If the grade in the final written exam is between 4,0 and 1,3, then the bonus improves the grade by one step (0,3 or 0,4).

**Prerequisites**

None

**Competence Goal**

The students understand, describe and use fundamental notions and techniques in graph theory. They can represent the appropriate mathematical questions in terms of graphs and use the results such as Menger's theorem, Kuratowski's theorem, Turan's theorem, as well as the developed proof ideas, to solve these problems. The students can analyze graphs in terms of their characteristics such as connectivity, planarity, and chromatic number. They are well positioned to understand graph theoretic methods and use them critically. Moreover, the students can communicate using English technical terminology.

**Content**

The course Graph Theory treats the fundamental properties of graphs, starting with basic ones introduced by Euler and including the modern results obtained in the last decade. The following topics are covered: structure of trees, paths, cycles and walks in graphs, minors, unavoidable subgraphs in dense graphs, planar graphs, graph coloring, Ramsey theory, and regularity in graphs.

**Annotation**

- Regular cycle: every 2nd year, winter semester
- Course is held in English
Module: Group Actions in Riemannian Geometry [M-MATH-102954]

**Responsible:** Prof. Dr. Wilderich Tuschmann

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Algebra and Geometry
- Complementary Field / Field Algebra and Geometry
- Mathematical Specialization
- Additional Examinations

**Credits:** 5

**Grading scale:** Grade to a tenth

**Recurrence:** Irregular

**Duration:** 1 term

**Level:** 4

**Version:** 1

**Mandatory**

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**Prerequisites**

none
Module: Growth and Agglomeration [M-WIWI-101496]

**Responsible:** Prof. Dr. Ingrid Ott
**Organisation:** KIT Department of Economics and Management
**Part of:** Complementary Field / Subject Economics

**Credits** 9  
**Grading scale** Grade to a tenth  
**Recurrence** Each term  
**Duration** 1 term  
**Language** German/English  
**Level** 4  
**Version** 5

### Compulsory Elective Courses (Elective: 9 credits)

<table>
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</table>

### Competence Certificate

The assessment is carried out as partial written exams (see the lectures descriptions). The overall grade for the module is the average of the grades for each course weighted by the credits.

### Prerequisites

None

### Modeled Conditions

The following conditions have to be fulfilled:

1. The course T-WIWI-102708 - Economics I: Microeconomics must have been started.
2. The course T-WIWI-102709 - Economics II: Macroeconomics must have been started.

### Competence Goal

The student

- gains deepened knowledge of micro-based general equilibrium models
- understands how based on individual optimizing decisions aggregate phenomena like economic growth or agglomeration (cities / metropolises) result
- is able to understand and evaluate the contribution of these phenomena to the development of economic trends
- can derive policy recommendations based on theory

### Content

The module includes the contents of the lectures *Endogenous Growth Theory*, *Spatial Economics* and *Dynamic Macroeconomics*. While the first lecture focuses on dynamic programming in modern macroeconomics, the other two lectures are more formal and analytical.

The common underlying principle of all three lectures in this module is that, based on different theoretical models, economic policy recommendations are derived.

### Workload

Total workload for 9 credit points: approx. 270 hours
The exact distribution is based on the credit points of the courses in the module.

### Recommendation

Attendance of the course *Introduction Economic Policy* [2560280] is recommended.

Successful completion of the courses *Economics I: Microeconomics* and *Economics II: Macroeconomics* is required.
# 3.84 Module: Harmonic Analysis [M-MATH-105324]

**Responsible:** Prof. Dr. Dorothee Frey  
**Organisation:** KIT Department of Mathematics  
**Part of:** 
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 2 / Field Analysis  
- Complementary Field / Field Analysis  
- Mathematical Specialization  
- Additional Examinations

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<tr>
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<td>Harmonic Analysis</td>
<td>8 CR</td>
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**Content**

- Fourier series  
- Fourier transform on L1 and L2  
- Tempered distributions and their Fourier transform  
- Explicit solutions of the Heat-, Schrödinger- and Wave equation in Rn  
- the Hilbert transform  
- the interpolation theorem of Marcinkiewicz  
- Singular integral operators  
- the Fourier multiplier theorem of Mihlin
3.85 Module: Harmonic Analysis 2 [M-MATH-106486]

**Responsible:** Prof. Dr. Dorothee Frey

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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**Competence Certificate**

Oral examination of ca. 30 minutes.

**Prerequisites**

None

**Module grade calculation**

The grade of the module is the grade of the oral exam.

**Workload**

Total workload: 240 hours

- Attendance: 90 h
  - lectures, problem classes and examination

- Self studies: 150 h
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research on the course content,
  - preparation for the module examination

**Recommendation**

The following modules are strongly recommended: "Harmonic Analysis", "Functional Analysis".
## 3.86 Module: Homotopy Theory [M-MATH-102959]

**Responsible:** Prof. Dr. Roman Sauer  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Complementary Field / Field Algebra and Geometry  
- Mathematical Specialization  
- Additional Examinations

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Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: Complementary Field / Subject Computer Science

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**Responsible:** Prof. Dr.-Ing. Jürgen Beyerer  
**Organisation:** KIT Department of Informatics  
**Part of:** Complementary Field / Subject Computer Science

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Module: Informatics [M-WIWI-101472]

**Responsible:**
Dr.-Ing. Tobias Käfer  
Prof. Dr. Sanja Lazarova-Molnar  
Prof. Dr. Andreas Oberweis  
Prof. Dr. Harald Sack  
Prof. Dr. Ali Sunyaev  
Prof. Dr. Alexey Vinel  
Prof. Dr. Melanie Volkamer  
Prof. Dr.-Ing. Johann Marius Zöllner

**Organisation:** KIT Department of Economics and Management

**Part of:** Complementary Field / Subject Economics

**Credits:** 9  
**Grading scale:** Grade to a tenth  
**Recurrence:** Each term  
**Duration:** 1 term  
**Level:** 4  
**Version:** 18

### Compulsory Elective Area (Election: )

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<td>T-WIWI-112690</td>
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<td>Management of IT-Projects</td>
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### Seminars and Advanced Labs (Election: between 0 and 1 items)

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Competence Certificate
The assessment is carried out as partial exams of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module. For passing the module exam in every singled partial exam the respective minimum requirements has to be achieved.

The examinations are offered every semester. Re-examinations are offered at every ordinary examination date. The assessment procedures are described for each course of the module separately.

When every singled examination is passed, the overall grade of the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

Prerequisites
It is only allowed to choose one lab.

Competence Goal
The student

- has the ability to master methods and tools in a complex discipline and to demonstrate innovativeness regarding the methods used,
- knows the principles and methods in the context of their application in practice,
- is able to grasp and apply the rapid developments in the field of computer science, which are encountered in work life, quickly and correctly, based on a fundamental understanding of the concepts and methods of computer science,
- is capable of finding and defending arguments for solving problems.

Content
The thematic focus will be based on the choice of courses in the areas of Applied Technical Cognitive Systems, Business Information Systems, Critical Information Infrastructures, Information Service Engineering, Security - Usability - Society or Web Science.

Workload
The total workload for this module is approximately 270 hours. The total number of hours per course is calculated from the time required to attend the lectures and exercises, as well as the examination times and the time required for an average student to achieve the learning objectives of the module.
3.90 Module: Information and Automation Technology [M-ETIT-106336]

Responsible: Prof. Dr.-Ing. Mike Barth
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Complementary Field / Subject Electrical Engineering

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<td>T-ETIT-112879</td>
<td>Information and Automation Technology - Lab Course</td>
<td>2 CR</td>
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Competence Certificate

1. The assessment of success takes the form of a written examination lasting 120 minutes. The module grade is the grade of the written exam.
2. A success check in the form of a coursework consisting of project documentation and checking the source code as part of the internship course

Prerequisites
None

Competence Goal
Students learn about the structure and functionality of information technology and automation systems, their architectures and their use.

The students:

- can name different programming languages and paradigms and compare their differences.
- know the components required to create an executable program and how they interact.
- know general computer architectures, their advantages and disadvantages as well as possibilities for increasing performance.
- know different ways of storing and organizing data in a structured way and can evaluate them.
- are able to explain the phases and processes of project management and can plan smaller projects.
- can apply modern methods and platforms for version management and describe the advantages and disadvantages.
- gain a basic understanding of current challenges in the engineering of (distributed) automation systems.
- are able to understand, apply and further develop the language tools of automation technology.
- are able to develop the architecture of an automation system with regard to communication, level and data flows.
- know basic information models of automation technology.

By participating in the practical course in information technology, students can break down complex programming problems into simple and clear modules and develop suitable algorithms and data structures, as well as convert these into an executable program using a programming language.
Content

Lecture

- Programming languages, program creation and program structures incl. object orientation
- Computer architectures
- data structures
- Project management
- Version management
- Theoretical and practical aspects of industrial automation technology.
- IEC61131-3 languages and program structure units
- Object-oriented aspects of control technology
- Live demos for control program design
- Deterministic systems for control technology
- Communication architectures and models
- AT architectures incl. modularization

Exercise

The exercise accompanies the lecture:

- teaches the basics of the C++ programming language. Exercises relating to the lecture material are set and the solutions are explained in detail. The focus is on the structure and analysis of programs and their creation.
- The basics of IEC 61131-3 control implementation are taught. Practical tasks are set and their solutions are discussed together. The focus is on the structure of control programs and their implementation and validation in real systems.

Practical course in information technology (6 sessions):

- The writing of complex C/C++ code sections and the use of an integrated development environment are practiced during the implementation in a structured and executable source code, in compliance with specified quality criteria. The implementation is carried out on a microcontroller board, which is already known from other courses. The project is carried out in small teams, which break down the overall project into individual tasks and work on them independently. The content of the lectures and exercises is taken up again and applied to specific problems. At the end of the practical course, each project team should demonstrate the successful completion of their work on the "Magni Silver Platform".

Module grade calculation

The module grade is the grade of the written exam.

Annotation

Attention: The partial performances assigned to this module are part of the orientation examination of the following study programs:

- Bachelor Elektrotechnik und Informationstechnik (SPO 2023, §8).

The examination is to be taken at the end of the 2nd semester. A repeat examination must be taken by the end of the 3rd semester.

Workload

1. Attendance time in lectures and exercises: 31 * 2 h = 62 h
2. Preparation/post-processing of the same: 45 h
3. Internship 6 appointments = 12 h
4. Preparation/follow-up of the internship = 50 h
5. Exam preparation and presence in the same: = 40 h

Total: 209 h = 7 LP

Recommendation

- Knowledge of the basics of programming is recommended (attendance of the MINT course C++).
- The contents of the module "Digital Technology" or "Fundamentals of Digital Technology (and Systems Modeling)" are helpful.
3.91 Module: Information Security [M-INFO-106015]

**Responsible:** Prof. Dr. Jörn Müller-Quade

**Organisation:** KIT Department of Informatics

**Part of:** Complementary Field / Subject Computer Science

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Module: Integral Equations [M-MATH-102874]

**Responsible:** PD Dr. Frank Hettlich

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Analysis
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Analysis
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

| T-MATH-105834 | Integral Equations | 8 CR | Arens, Griesmaier, Hettlich |

**Competence Certificate**
The module will be completed by an oral exam (~30 min.).

**Prerequisites**
none

**Competence Goal**
The students can clarify integral equations and can show existence and uniqueness of solutions by perturbation theory and by Fredholm theory. Ideas of proofs for Fredholm theory and perturbation theory especially in case of convolution equations can be described and explained. Furthermore, the students can formulate classical boundary value problems for ordinary differential equations and from potential theory in terms of integral equations.

**Content**
- Riesz and Fredholm theory
- Fredholm and Volterra integral equations
- Applications in potential theory
- Convolution equation

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 240h
Attendance: 90h
- Lecture, problem class, examination
Self studies: 150h
- follow-up and deepening of the course content
- work on problem sheets
- literature studies and internet research related to the course content
- preparation of the module examination
3.93 Module: Internet Seminar for Evolution Equations [M-MATH-102918]

**Responsible:** Prof. Dr. Roland Schnaubelt

**Organisation:** KIT Department of Mathematics

**Part of:** Mathematical Methods 1 / Field Analysis
Mathematical Methods 2 / Field Analysis
Complementary Field / Field Analysis
Mathematical Specialization
Additional Examinations

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**Mandatory**

| T-MATH-105890 | Internet Seminar for Evolution Equations | 8 CR | Frey, Kunstmann, Schnaubelt, Tolksdorf |

**Competence Certificate**
The module will be completed by an oral exam (ca. 30 min).

**Prerequisites**
none

**Competence Goal**
Students can explain the basic ideas, concepts and statements of a sub-area of the theory of evolutionary equations and apply them to examples. They can work on this topic from a script and discuss it in a reading course.

**Content**
A part of the theory of evolution equations is introduced. The necessary basics (beyond the contents of an introductory lecture in functional analysis) are developed. The basic concepts, statements and methods of the respective subarea are treated systematically. Applications of the theory are discussed.

**Module grade calculation**
The grade of the module is the grade of the oral exam.

**Annotation**
The internet seminar has different main organizers each year, who send out a manuscript with exercises and provide a website with discussion forums. In Karlsruhe, the material is discussed in a two-hour reading course in the winter semester, which is roughly equivalent to a four-hour lecture with exercises. There is the opportunity (outside of our modules) to work on a project during the summer semester and present it at a final workshop in June. Further information and details on the current content can be found on Roland Schnaubelt's website, [http://www.math.kit.edu/iana3/~schnaubelt/en](http://www.math.kit.edu/iana3/~schnaubelt/en)

**Workload**
Total workload: 240 hours

**Attendance:**
30 h
- lectures and examination

**Self studies:** 210 h
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

**Recommendation**
The contents of the module "Functional Analysis" are strongly recommended.
### 3.94 Module: Introduction into Particulate Flows [M-MATH-102943]

<table>
<thead>
<tr>
<th>Responsible</th>
<th>Prof. Dr. Willy Dörfler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>KIT Department of Mathematics</td>
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</tbody>
</table>
| Part of     | Mathematical Methods 1 / Field Applied and Numerical Mathematics  
             | Mathematical Methods 2 / Field Applied and Numerical Mathematics  
             | Complementary Field / Field Applied and Numerical Mathematics  
             | Mathematical Specialization  
             | Additional Examinations |
| Credits     | 3 |
| Grading scale | Grade to a tenth |
| Recurrence  | Once |
| Duration    | 1 term |
| Level       | 4 |
| Version     | 1 |

<table>
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<tbody>
<tr>
<td>T-MATH-105911</td>
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</table>

**Prerequisites**
none
Module: Introduction to Aperiodic Order [M-MATH-105331]

### Responsible
Prof. Dr. Tobias Hartnick

### Organisation
KIT Department of Mathematics

### Part of
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Algebra and Geometry
- Complementary Field / Field Algebra and Geometry
- Mathematical Specialization
- Additional Examinations

### Credits
3

### Grading scale
Grade to a tenth

### Recurrence
Irregular

### Duration
1 term

### Level
4

### Version
1

### Mandatory
| T-MATH-110811 | Introduction to Aperiodic Order | 3 CR | Hartnick |

### Prerequisites
None
3.96 Module: Introduction to Artificial Intelligence [M-INFO-106014]

**Responsible:** TT-Prof. Dr. Pascal Friederich  
Prof. Dr. Gerhard Neumann

**Organisation:** KIT Department of Informatics  
Part of: Complementary Field / Subject Computer Science

<table>
<thead>
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<th>Level</th>
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**Mandatory**

| T-INFO-112194 | Introduction to Artificial Intelligence | 5 CR | Friederich, Neumann |
Module: Introduction to Convex Integration [M-MATH-105964]

### Responsible
Prof. Dr. Wolfgang Reichel

### Organisation
KIT Department of Mathematics

### Part of:
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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### Competence Certificate
The module will be completed with an oral exam (approx. 30 min).

### Prerequisites
none

### Competence Goal
The main aim of this lecture is to introduce students to convex integration as a tool to construct solutions to partial differential equations. In particular, they will be able to

- discuss the structure of convex integration algorithms,
- state major theorems and their relation,
- discuss regularity of convex integration solutions and uniqueness,
- discuss building blocks of constructions and their properties.

### Content
This lecture provides an introduction to the methods of convex integration and its applications:

- for isometric immersions,
- for the m-well problem in elasticity,
- for equations of fluid dynamics and
- higher regularity of convex integration solutions.

### Module grade calculation
The grade of the module is the grade of the oral exam.

### Workload
Total workload: 90 hours

**Attendance:** 30 h

- lectures and examination

**Self studies:** 60 h

- follow-up and deepening of the course content,
- literature study and internet research on the course content,
- preparation for the module examination

### Recommendation
The modules "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.
### Module: Introduction to Dynamical Systems [M-MATH-106591]

**Responsible:** Prof. Dr. Wolfgang Reichel  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 2 / Field Analysis  
- Complementary Field / Field Analysis  
- Mathematical Specialization  
- Additional Examinations

<table>
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<th>Language</th>
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<td>T-MATH-113263</td>
<td>Introduction to Dynamical Systems</td>
<td>6</td>
<td>de Rijk, Reichel</td>
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</tbody>
</table>

**Competence Certificate**
The module will be completed with an oral exam of about 30 minutes.

**Prerequisites**
None

**Competence Goal**
After successful completion of this module students
- can explain the significance of dynamical systems and give several examples;
- have acquired miscellaneous tools to prove the existence of special solutions and to analyze the local dynamics around them;
- master several techniques to describe global dynamics in certain classes of dynamical systems;
- identify various bifurcations and explain how these change the dynamics of the system;
- outline the main steps in establishing chaotic behavior.

**Content**
- Flows  
- Abstract dynamical systems  
- Lyapunov functions  
- Invariant sets  
- Limit sets and attractors  
- Hartman-Grobman theorem  
- Local (un)stable manifold theorem  
- Poincaré-Bendixson theorem  
- Periodic orbits and Floquet theory  
- Exponential dichotomies  
- Melnikov functions  
- Lin's method  
- Hamiltonian dynamics  
- Liénard systems  
- Bifurcations  
- Chaotic dynamics  
- (Introduction to) Fenichel theory  
- Center manifolds  
- Dynamical systems associated with semilinear evolution equations

**Module grade calculation**
The module grade is the grade of the oral exam.
**Workload**

Total workload: 180 hours

Attendance: 60 h

- lectures, problem classes and examination

Self studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

**Recommendation**

The following modules are strongly recommended: Analysis 1-2 and Linear Algebra 1-2. The module Analysis 4 is recommended.
Module: Introduction to Fluid Dynamics [M-MATH-105650]

**Responsible:** Prof. Dr. Wolfgang Reichel

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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<th>Level</th>
<th>Version</th>
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<tr>
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<td>Introduction to Fluid Dynamics</td>
<td>3</td>
<td>CR</td>
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<td>1 term</td>
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</table>

**Competence Certificate**
The module will be completed by an oral exam (approx. 30 min).

**Prerequisites**
None

**Competence Goal**
The main aim of this lecture is to introduce students to mathematical fluid dynamics. In particular, by the end of the course students will be able to

- discuss and explain the various formulations of the Euler equations and when these formulations are equivalent,
- state major theorems and their relation,
- discuss weak formulations, existence and uniqueness results.

**Content**
Mathematical description and analysis of fluid dynamics:

- physical motivation of the incompressible Euler and Navier-Stokes equations,
- Vorticity-Stream formulation and Eulerian and Lagrangian coordinates,
- Local existence theory and energy methods,
- Weak solutions and the Beale-Kato-Majda criterion.

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 90 hours

**Attendance:**
- 30 hours
  - lectures, problem classes, and examination

**Self-studies:**
- 60 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

**Recommendation**
The contents of the courses "Classical Methods for Partial Differential Equations" or "Boundary and Eigenvalue Problems" are recommended.
3.100 Module: Introduction to Fluid Mechanics [M-MATH-106401]

**Responsible:** TT-Prof. Dr. Xian Liao

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

**Credits:** 6

**Grading scale:** Grade to a tenth

**Recurrence:** Irregular

**Duration:** 1 term

**Language:** English

**Level:** 4

**Version:** 1

**Mandatory**

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<td>Introduction to Fluid Mechanics</td>
<td>6 CR Liao</td>
</tr>
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</table>

**Competence Certificate**
The module examination takes the form of an oral examination of approx. 25 minutes.

**Prerequisites**
None

**Competence Goal**
Graduates can
- recognize the essential formulations of the partial differential equations in fluid mechanics and explain them using examples,
- use techniques to describe the weak and strong solutions for the Euler and Navier-Stokes equations, and show the existence, uniqueness and regularity results,
- name the special difficulties in the three-dimensional case,
- understand the concept of stratification and explain it using concrete examples.

**Content**
- Derivation of models, modeling
- Euler equations, Navier-Stokes equations
- Biot-Savart law, Leray-Hopf decomposition
- Wellposedness results
- Regularity results

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
total work load: 180 hours

**Recommendation**
The module *Functional Analysis* is strongly recommended.
Module: Introduction to Geometric Measure Theory [M-MATH-102949]

Responsible: PD Dr. Steffen Winter
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Algebra and Geometry
Mathematical Methods 2 / Field Algebra and Geometry
Complementary Field / Field Algebra and Geometry
Mathematical Specialization
Additional Examinations

Credits 6
Grading scale Grade to a tenth
Recurrence Irregular
Duration 1 term
Level 4
Version 1

Mandatory

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<td>Introduction to Geometric Measure Theory</td>
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</table>

Prerequisites
none
# Module: Introduction to Homogeneous Dynamics [M-MATH-105101]

**Responsible:** Prof. Dr. Tobias Hartnick  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 1 / Field Stochastics  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Analysis  
- Mathematical Methods 2 / Field Stochastics  
- Complementary Field / Field Algebra and Geometry  
- Complementary Field / Field Analysis  
- Complementary Field / Field Stochastics  
- Mathematical Specialization  
- Additional Examinations

<table>
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<th>Duration</th>
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**Mandatory**  
| T-MATH-110323 | Introduction to Homogeneous Dynamics | 6 CR | Hartnick |

**Prerequisites**  
None
Module: Introduction to Kinetic Equations [M-MATH-105837]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Analysis
          Mathematical Methods 2 / Field Analysis
          Complementary Field / Field Analysis
          Mathematical Specialization
          Additional Examinations

Credits 3
Grading scale Grade to a tenth
Recurrence Irregular
Duration 1 term
Language English
Level 4
Version 2

Mandatory
T-MATH-111721 Introduction to Kinetic Equations 3 CR Zillinger

Competence Certificate
oral examination of approx. 30 minutes

Prerequisites
none

Competence Goal
The main aim of this lecture is to introduce students to the theory of kinetic transport equations. In particular, by the end of the course students will be able to

- discuss properties of the free transport, Boltzmann and Vlasov-Poisson equations,
- state major theorems and their relation,
- discuss notions of solutions and their properties,
- discuss the effects of phase mixing and challenges of nonlinear equations.

Content
Mathematical description and analysis of kinetic transport equations:

- the free transport, Boltzmann and Vlasov-Poisson equations,
- linear theory, phase mixing and Landau damping,
- equilibrium solutions and stability,
- nonlinear results and methods,
- renormalized solutions.

Module grade calculation
The module grade is the grade of the final oral exam.

Workload
Total workload: 90 h
Attendance: 30 h
- lectures and examination
Self studies: 60 h
- follow-up and deepening of the course content,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendation
The contents of the course "Classical Methods for Partial Differential Equations" are recommended.
Module: Introduction to Kinetic Theory [M-MATH-103919]

Responsible: Prof. Dr. Martin Frank
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
          Mathematical Methods 2 / Field Applied and Numerical Mathematics
          Complementary Field / Field Applied and Numerical Mathematics
          Mathematical Specialization
          Additional Examinations

<table>
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<th>Recurrence</th>
<th>Duration</th>
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<th>Level</th>
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<td>T-MATH-108013</td>
<td>Introduction to Kinetic Theory</td>
<td>4 CR</td>
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</table>

Prerequisites
None

Competence Goal
After successfully taking part in the module’s classes and exams, students have gained knowledge and abilities as described in the “Inhalt” section. Specifically, Students know common means of mesoscopic and macroscopic description of particle systems. Furthermore, students are able to describe the basics of multiscale methods, such as the asymptotic analysis and the method of moments. Students are able to apply numerical methods to solve engineering problems related to particle systems. They can name the assumptions that are needed to be made in the process. Students can judge whether specific models are applicable to the specific problem and discuss their results with specialists and colleagues.

Content
- From Newton's equations to Boltzmann's equation
- Rigorous derivation of the linear Boltzmann equation
- Properties of kinetic equations (existence & uniqueness, H theorem)
- The diffusion limit
- From Boltzmann to Euler & Navier-Stokes
- Method of Moments
- Closure techniques
- Selected numerical methods

Recommendation
Partial Differential Equations, Functional Analysis
3.105 Module: Introduction to Microlocal Analysis [M-MATH-105838]

**Responsible:** TT-Prof. Dr. Xian Liao

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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<th>Module Title</th>
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<tbody>
<tr>
<td>T-MATH-111722</td>
<td>Introduction to Microlocal Analysis</td>
<td>3 CR</td>
</tr>
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</table>

**Competence Certificate**
oral examination of circa 30 minutes

**Prerequisites**
none

**Competence Goal**

- Students will become familiar with the notions of Fourier multipliers and pseudo-differential operators
- Students can state major theorems and their relation
- Students will understand the structure of the propagation of singularities by introducing the wave front set and apply them to the domain of partial differential equations, control theory, etc.

**Content**

1. Pseudo-differential operators
2. Symbolic calculus
3. Wavefront set
4. Propagation of singularities
5. Microlocal defective measure

**Module grade calculation**
The module grade is the grade of the final oral exam.

**Workload**

Total workload: 90 h

- Attendance: 30 h
  
  - lectures and examination

Self studies: 60 h

  - follow-up and deepening of the course content,
  - literature study and internet research on the course content,
  - preparation for the module examination

**Recommendation**
The following courses should be studied beforehand: "Classical Methods for Partial Differential Equations" und "Functional Analysis".
3.106 Module: Introduction to Scientific Computing [M-MATH-102889]

Responsible: Prof. Dr. Willy Dörfler  
Prof. Dr. Tobias Jahnke

Organisation: KIT Department of Mathematics

Part of:  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
- Additional Examinations

<table>
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Mandatory

| T-MATH-105837 | Introduction to Scientific Computing | 8 CR | Dörfler, Hochbruck, Jahnke, Rieder, Wieners |

Competence Certificate

The module will be completed by an oral exam (about 30 min).

Prerequisites

None

Competence Goal

At the end of the course, students
- are able to develop the interlinking of all aspects of scientific computing using simple examples: from modeling and algorithmic implementation to stability and error analysis.
- can explain concepts of modeling with differential equations
- are able to implement simple application examples algorithmically, evaluate the code and present and discuss the results.

Content

- Numerical methods for initial value problems, boundary value problems, and initial boundary value problems
- Modelling with differential equations
- Algorithmic realization of applications
- Presentation of results of scientific computations

Module grade calculation

The module grade is the grade of the oral exam.

Annotation

3 SWS lecture plus 3 SWS hands-on training

Workload

Total workload: 240 hours

Attendance: 90 hours
- lectures, problem classes, and examination

Self-studies: 150 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination
**Recommendation**

It is strongly recommended that participants have completed the modules "Numerische Mathematik 1 und 2" as well as "Programmieren: Einstieg in die Informatik und algorithmische Mathematik".
**3.107 Module: Introduction to Stochastic Differential Equations [M-MATH-106045]**

**Responsible:** Prof. Dr. Mathias Trabs

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

<table>
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<th>Level</th>
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**Mandatory**

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<th>Introduction to Stochastic Differential Equations</th>
<th>4 CR</th>
<th>Janák, Trabs</th>
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</table>

**Competence Certificate**
The module will be completed with an oral exam (approx. 30 min).

**Prerequisites**
none

**Competence Goal**
The students will
- know fundamental examples for linear and non-linear stochastic differential equations,
- be able to apply basic solution concepts for stochastic differential equations,
- know fundamental theorems of stochastic calculus and will be able to apply these to stochastic differential equations.

**Content**
1. Introduction and recapitulation of stochastic integration, Itô’s formula, Lévy Theorem
2. Burkholder-Davis-Gundy inequality
3. Existence and uniqueness of solutions of stochastic differential equations
4. Explicit solutions of linear stochastic differential equations
5. Change of the time scale of Brownian motion
6. Representation of continuous time martingales
7. Brownian martingales
8. Local and global solutions of stochastic differential equations
9. Girsanov Theorem

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 120 hours

**Attendance:** 45 hours
- lectures, problem classes, and examination

**Self-studies:** 75 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination
**Recommendation**
The contents of the course "Probability Theory" are strongly recommended. The contents of the course "Continuous Time Finance" are recommended.
Module: Inverse Problems [M-MATH-102890]

Responsibility: Prof. Dr. Roland Griesmaier
Organisation: KIT Department of Mathematics

Part of:
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Analysis
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Analysis
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

Credits: 8
Grading scale: Grade to a tenth
Recurrence: Each winter term
Duration: 1 term
Level: 4
Version: 1

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<tbody>
<tr>
<td>T-MATH-105835</td>
<td>Inverse Problems</td>
<td>8 CR</td>
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</tbody>
</table>

| Authors       | Arens, Griesmaier, Hettlich, Rieder |

Competence Certificate
The module will be completed by an oral exam (approx. 30 min).

Prerequisites
None

Competence Goal
At the end of the course, students are able to distinguish well-posed from ill-posed problems. They acquire a systematic knowledge of the theory of linear inverse problems and their regularization in Hilbert spaces and can provide proof ideas. They are able to analyze regularization methods such as, e.g., Tikhonov regularization and assess their convergence properties.

Content
- Compact operator equations
- Ill-posed problems
- Regularization
- Tikhonov regularization
- Iterative regularization
- Examples for ill-posed problems

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours
- lectures, problem classes, and examination

Self-studies: 150 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendation
The course "Functional Analysis" or "Integral Equations" is recommended as a prerequisite.
3.109 Module: IT Security [M-INFO-106315]

**Responsible:** Prof. Dr. Hannes Hartenstein  
Prof. Dr. Jörn Müller-Quade  
Prof. Dr. Thorsten Strufe  
TT-Prof. Dr. Christian Wressnegger

**Organisation:** KIT Department of Informatics  
Part of: Complementary Field / Subject Computer Science

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**Mandatory**

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<td>T-INFO-112818</td>
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<td>Hartenstein, Müller-Quade, Strufe, Wressnegger</td>
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</table>

**Competence Certificate**
See partial achievements (Teilleistung)

**Prerequisites**
See partial achievements (Teilleistung)

**Competence Goal**
Students
- have in-depth knowledge of cryptography and IT security
- know and understands sophisticated techniques and security primitives to achieve the protection goals
- know and understand scientific evaluation and analysis methods of IT security (game-based formalization of confidentiality and integrity, security and anonymity notions)
- have a good understanding of types of data, personal data, legal and technical fundamentals of privacy protection
- know and understand the fundamentals of system security (buffer overflow, return-oriented programming, ...)  
- know different mechanisms for anonymous communication (TOR, Nym, ANON) and can assess their effectiveness

**Content**
This advanced mandatory module deepens different topics of IT security. These include in particular:
- Elliptic curve cryptography
- Threshold cryptography
- Zero-knowledge proofs
- Secret sharing
- Secure multi-party computation and homomorphic encryption
- Methods of IT security (game-based analysis and the UC model)
- Crypto-currencies and consensus through proof-of-work/stake
- Anonymity on the internet, anonymity with online payments
- Privacy-preserving machine learning
- Security of machine learning
- System security and exploits
- Threat modeling and quantification of IT security

**Workload**
Course workload:
1. Attendance time: 56 h
2. Self-study: 56 h
3. Preparation for the exam: 68 h

**Recommendation**
Attendance of the lecture Information Security is recommended.
Literature

Literature:
• Katz/Lindell: Introduction to Modern Cryptography (Chapman & Hall)
• Schäfer/Roßberg: Netz sicherheit (dpunkt)
• Anderson: Security Engineering (Wiley, and online)
• Stallings/Brown: Computer Security (Pearson)
• Pfleeger, Pfleeger, Margulies: Security in Computing (Prentice Hall)
### Module: Key Competences [M-MATH-103053]

**Organisation:** KIT Department of Mathematics  
**Part of:** Interdisciplinary Qualifications

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**Election notes**  
For self assignment of taken interdisciplinary qualifications of HoC, ZAK or SPZ the 'Teilleistungen' with the title "Self Assignment HoC-ZAK-SPZ ..." have to be selected according to the grading scale, not graded or graded.

#### Key Competences (Election: at least 6 credits)

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**Prerequisites**  
None
### 3.111 Module: Key Moments in Geometry [M-MATH-104057]

**Responsible:** Prof. Dr. Wilderich Tuschmann  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Complementary Field / Field Algebra and Geometry  
- Mathematical Specialization  
- Additional Examinations

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**Prerequisites**  
None
Module: L2-Invariants [M-MATH-102952]

**Responsible:** Dr. Holger Kammeyer

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Algebra and Geometry
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

**Credits:** 5

**Grading scale:** Grade to a tenth

**Recurrence:** Irregular

**Duration:** 1 term

**Level:** 4

**Version:** 1

### Mandatory

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**Prerequisites**

none
Module: Lie Groups and Lie Algebras [M-MATH-104261]

**Responsible:** Prof. Dr. Tobias Hartnick

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Algebra and Geometry
- Complementary Field / Field Algebra and Geometry
- Mathematical Specialization
- Additional Examinations

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Mathematics Master 2016 (Master of Science (M.Sc.))
Module Handbook as of 09/07/2024
### Module: Lie-Algebras (Linear Algebra 3) [M-MATH-105839]

**Responsible:** Prof. Dr. Tobias Hartnick  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Complementary Field / Field Algebra and Geometry  
- Mathematical Specialization  
- Additional Examinations

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3.115 Module: Linear Electronic Networks [M-ETIT-101845]

**Mandatory**

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**Competence Certificate**
The content of the course Linear Electronic Networks (7 CP) will be checked in a written exam lasting 120 minutes. If the exam is passed, students can receive a grade bonus of up to 0.4 grade points if two project tasks have been successfully completed during the semester. The processing of the project tasks is evidenced by the submission of documentation or the project code.

**Competence Goal**
In the Linear Electrical Networks module, the student acquires skills in the analysis and design of electrical circuits with linear components with direct current and alternating current. Here he is able to remember and understand the topics, and also to use the methods dealt with in order to analyze the electrical circuits with linear components and to assess their relevance, correct function and properties.

**Content**
Methods for the analysis of complex linear electrical circuits, Definitions of U, I, R, L, C, independent sources, dependent sources, Kirchhoff's equations, node potential method, mesh current method, equivalent voltage and current source, star-delta transformation, power matching, Operational amplifier, inverting amplifier, adder, voltage follower, non-inverting amplifier, differential amplifier, Sinusoidal currents and voltages, differential equations for L and C, complex numbers, Description of RLC circuits with complex numbers, impedance, complex power, power matching, Bridge circuits, Wheatstone, Maxwell and bridge circuits, Series and parallel resonant circuits, two port theory, Z, Y and A matrix, impedance transformation, locus curve and Bode diagram, Transformer, mutual inductance, transformer equations, equivalent circuits of the transformer, Three-phase current, power transmission and symmetrical load.

**Module grade calculation**
The module grade corresponds to the grade of the partial performance linear electrical networks. As described in the section "Success assessment (s)", this is composed of the grade of the written exam Linear Electrical Networks and any grade bonus received.

**Annotation**
Attention: This module is part of the orientation test according to the SPO Bachelor Electrical Engineering and Information Technology.

**Workload**
The workload of the LV Linear Electrical Networks falls

1. Presence time in lectures, exercises
2. Preparation / post-processing
3. Exam preparation and presence in the same

The workload for point 1 corresponds to approximately 60 hours, for points 2-3 approximately 115 to 150 hours. The total workload for the LV Linear Electrical Networks is 175-210 hours. This corresponds to 7 LP.
3.116 Module: Localization of Mobile Agents [M-INFO-100840]

**Responsible:** Prof. Dr.-Ing. Uwe Hanebeck

**Organisation:** KIT Department of Informatics

**Part of:** Complementary Field / Subject Computer Science

<table>
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<td>Localization of Mobile Agents</td>
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Module: Markov Decision Processes [M-MATH-102907]

**Responsible:** Prof. Dr. Nicole Bäuerle  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Stochastics  
- Mathematical Methods 2 / Field Stochastics  
- Complementary Field / Field Stochastics  
- Mathematical Specialization  
- Additional Examinations

<table>
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**Competence Certificate**  
The module will be completed by an oral exam (about 20 min).

**Prerequisites**  
none

**Competence Goal**  
At the end of the course, students

- can name the mathematical foundations of Markov Decision Processes and apply solution algorithm,  
- can formulate stochastic, dynamic optimization problems as Markov Decision Processes,  
- are able to work in a self-organized and reflective manner.

**Content**

- MDPs with finite time horizon  
  - Bellman equation  
  - Problems with structure  
  - Applications  
- MDPs with infinite time horizon  
  - contracting MDPs  
  - positive MDPs  
  - Howards policy improvement  
  - Solution by linear programs  
- Stopping problems  
  - finite and infinite time horizon  
  - One-step-look-ahead rule

**Module grade calculation**  
The module grade is the grade of the oral exam.

**Workload**  
Total workload: 150 hours  
Attendance: 60 hours  
- lectures, problem classes, and examination  
Self-studies: 90 hours  
- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research relating to the course content,  
- preparation for the module examination
Recommendation
The course 'Probability theory' is strongly recommended and 'Markov chains' is recommended.
3.118 Module: Master’s Thesis [M-MATH-102917]

**Responsible:** PD Dr. Stefan Kühnlein

**Organisation:** KIT Department of Mathematics

**Part of:** Master’s Thesis

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**Competence Certificate**

The Master’s Thesis is graded according to the regulations from §14 (7) of Studien- und Prüfungsordnung. The handling time is six months. On submission of the Master’s Thesis, according to §14 (5) the students have to confirm, that the thesis has been written independently without using undisclosed sources and tools, that passages which have been copied literally or in content have clearly been marked as such, and that the by-laws to implement scientific integrity at KIT in the recent version have been taken into account. If this confirmation is not contained, the thesis gets rejected. In case of a wrong confirmation, the thesis is graded with “not sufficient” (5.0). The thesis may be written in English.

If the thesis is planned to be written outside the KIT-department of mathematics, the approval by the examination board is required. If the thesis is planned to be written outside the KIT-department of mathematics, the approval by the examination board is required. Further details are regulated by §14 of Studien- und Prüfungsordnung.

**Prerequisites**

For admission to the module Master’s Thesis it is required that the student has successfully accomplished module examinations of at least 70 credit points.

**Modeled Conditions**

The following conditions have to be fulfilled:

1. You need to have earned at least 70 credits in the following fields:
   - Complementary Field
   - Mathematical Methods 1
   - Mathematical Methods 2
   - Mathematical Specialization
   - Mathematical Seminar
   - Interdisciplinary Qualifications

**Competence Goal**

The students are able to work on a given topic independently and in a limited time, using scientific methods from the state of the art. They master the necessary scientific methods and techniques, modify them if necessary and develop them further if required. Alternative approaches are compared critically. In their thesis, the students write up their results clearly structured and in a way adequate to academic standards.

**Content**

Following §14 SPO the thesis should demonstrate that the students are able to work on a given topic from their course of studies independently and in a bounded time, using scientific methods from the state of the art. The students should have the opportunity to make suggestions for their topic. If the student petitions, in exceptional cases the head of the examination board takes care that the student receives a topic for a master thesis within four weeks. In that case, the topic is given by the head of the examination board. Further details are regulated by §14 of Studien- und Prüfungsordnung.

**Workload**

Total work load: 900 hours

Attendance: 0 hours

Self studies: 900 hours
3.119 Module: Mathematical Methods in Signal and Image Processing [M-MATH-102897]

**Responsible:** Prof. Dr. Andreas Rieder  
**Organisation:** KIT Department of Mathematics

**Part of:**  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
- Additional Examinations

**Credits:** 8  
**Grading scale:** Grade to a tenth  
**Recurrence:** Irregular  
**Duration:** 1 term  
**Level:** 4  
**Version:** 1

| Mandatory | T-MATH-105862 | Mathematical Methods in Signal and Image Processing | 8 CR | Rieder |

**Competence Certificate**  
Success is assessed in the form of an oral examination lasting approx. 30 minutes.

**Prerequisites**  
none

**Competence Goal**  
Graduates know the essential mathematical tools of signal and image processing and their properties. They are able to apply these tools appropriately and to scrutinize and evaluate the results obtained.

**Content**  
- Digital and analog systems  
- Integral Fourier transform  
- Sampling and resolution  
- Discrete and fast Fourier transform  
- Non-uniform sampling  
- Anisotropic diffusion filters  
- Variational methods

**Module grade calculation**  
The module grade is the grade of the oral exam.

**Workload**  
Total workload: 240 hours  
Attendance: 90 hours  
- lectures, problem classes, and examination

Self-studies: 150 hours  
- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research relating to the course content,  
- preparation for the module examination

**Recommendation**  
The course “Functional analysis” is recommended.
Module: Mathematical Methods of Imaging [M-MATH-103260]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

Credits
Grading scale
Recurrence
Duration
Level
Version

Mandatory

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Competition Certificate
Success is assessed in the form of an oral examination lasting approx. 30 minutes.

Prerequisites
None

Competence Goal
Graduates become familiar with some imaging methods and are able to discuss and analyze the underlying mathematical aspects. In particular, they will be able to explain the functional-analytical properties of the imaging operators. They can implement the corresponding reconstruction algorithms and they can explain and evaluate the artifacts that appear. They are able to apply the techniques they have learned to related problems.

Content
- Variants of tomography (X-ray, impedance, seismic, etc.)
- Properties of (generalized) Radon transforms
- Microlocal analysis/Pseudodifferential operators
- Ill-Posedness and regularization
- Reconstruction algorithms

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total work load: 150 hours
Attendance: 60 hours
  - lectures, problem classes, and examination
Self-studies: 90 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

Recommendation
The course „Functional Analysis“ is recommended.
Module: Mathematical Modelling and Simulation in Practise [M-MATH-102929]

Responsible: PD Dr. Gudrun Thäter
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

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### Competence Certificate

The module will be completed by an oral exam (ca. 20 min).

### Prerequisites

None

### Competence Goal

The general aim of this lecture course is threefold:

1) to interconnect different mathematical fields,
2) to connect mathematics and real life problems,
3) to learn to be critical and to ask relevant questions.

At the end of the course, students can

- work Project-orientated,
- link knowledge from different fields,
- develop typical modelling approaches on their own.

### Content

Mathematical thinking (as modelling) and mathematical techniques (as tools) meet application problems such as:

- Differential equations
- Population models
- Traffic flow
- Game theory
- Chaos
- Mechanics and fluids

### Module grade calculation

The module grade is the grade of the oral exam.

### Annotation

The lecture is always in English.

To earn the credits you have to attend the lecture, finish the work on one project during the term in a group of 2-3 persons and pass the exam. The topic of the project is up to the choice of each group.
Workload
Total workload: 120 hours
Attendance: 45 hours
  - lectures, problem classes, and examination
  - Project presentations
Self-studies: 75 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination,
  - work on the project

Recommendation
Some basic knowledge of numerical mathematics is recommended.

Literature
### 3.122 Module: Mathematical Physics [M-MATH-103079]

**Responsible:** Prof. Dr. Dirk Hundertmark  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 2 / Field Analysis  
- Complementary Field / Field Analysis  
- Mathematical Specialization  
- Additional Examinations

<table>
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<tr>
<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
<th>Level</th>
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<td>1 term</td>
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**Mandatory**

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<tr>
<td>T-MATH-106113</td>
<td>Mathematical Physics</td>
<td>8</td>
<td>CR</td>
<td>Hundertmark</td>
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</table>

**Prerequisites**

None
### M 3.123 Module: Mathematical Physics 2 [M-MATH-103274]

- **Responsible:** Prof. Dr. Dirk Hundertmark
- **Organisation:** KIT Department of Mathematics
- **Part of:**
  - Mathematical Methods 1 / Field Analysis
  - Mathematical Methods 2 / Field Analysis
  - Complementary Field / Field Analysis
  - Mathematical Specialization
  - Additional Examinations

<table>
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<td>Irregular</td>
<td>1 term</td>
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**Mandatory**

| T-MATH-106526 | Mathematical Physics 2 | 8 CR | Hundertmark |

**Prerequisites**

None
Module: Mathematical Programming [M-WIWI-101473]

### Responsible
Prof. Dr. Oliver Stein

### Organisation
KIT Department of Economics and Management

### Part of
Complementary Field / Subject Economics

#### Credits 9

#### Grading scale Grade to a tenth

#### Recurrence Each term

#### Duration 1 term

#### Language German/English

#### Level 4

#### Version 8

### Compulsory Elective Courses (Election: at most 2 items)

<table>
<thead>
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<th>Course Code</th>
<th>Course Name</th>
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<tr>
<td>T-WIWI-102726</td>
<td>Global Optimization I</td>
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<tr>
<td>T-WIWI-103638</td>
<td>Global Optimization I and II</td>
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<td>T-WIWI-102856</td>
<td>Convex Analysis</td>
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<tr>
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<td>Multicriteria Optimization</td>
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<td>Parametric Optimization</td>
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### Supplementary Courses (Election: at most 2 items)

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<td>4,5 CR</td>
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<tr>
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<td>Multivariate Statistical Methods</td>
<td>4,5 CR</td>
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<td>Nonlinear Optimization II</td>
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<tr>
<td>T-WIWI-102715</td>
<td>Operations Research in Supply Chain Management</td>
<td>4,5 CR</td>
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<td>Topics in Stochastic Optimization</td>
<td>4,5 CR</td>
<td>Rebennack</td>
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</tbody>
</table>

### Competence Certificate
The assessment is carried out as partial exams (according to Section 4(2), 1 or 2 of the examination regulation) of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module. The assessment procedures are described for each course of the module separately.

The overall grade of the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

### Prerequisites
At least one of the courses "Mixed Integer Programming I", "Multicriteria Optimization", "Convex Analysis", "Parametric Optimization", "Nonlinear Optimization I" and "Global Optimization I" has to be taken.

### Competence Goal
The student

- names and describes basic notions for advanced optimization methods, in particular from continuous and mixed integer programming,
- knows the indispensable methods and models for quantitative analysis,
- models and classifies optimization problems and chooses the appropriate solution methods to solve also challenging optimization problems independently and, if necessary, with the aid of a computer,
- validates, illustrates and interprets the obtained solutions,
- identifies drawbacks of the solution methods and, if necessary, is able to makes suggestions to adapt them to practical problems.

### Content
The module focuses on theoretical foundations as well as solution algorithms for optimization problems with continuous and mixed integer decision variables.
Annotation
The lectures are partly offered irregularly. The curriculum of the next three years is available online (www.ior.kit.edu).
For the lectures of Prof. Stein a grade of 30 % of the exercise course has to be fulfilled. The description of the particular lectures is more detailed.

Workload
The total workload for this module is approximately 270 hours.
3.125 Module: Mathematical Statistics [M-MATH-102909]

Responsible: PD Dr. Bernhard Klar
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: Mathematical Methods 1 / Field Stochastics
Mathematical Methods 2 / Field Stochastics
Complementary Field / Field Stochastics
Mathematical Specialization
Additional Examinations

<table>
<thead>
<tr>
<th>Credits</th>
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<th>Recurrence</th>
<th>Duration</th>
<th>Level</th>
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Mandatory

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<tr>
<td>T-MATH-105872</td>
<td>Mathematical Statistics</td>
<td>8 CR</td>
</tr>
</tbody>
</table>

Competence Certificate
The module will be completed by an oral exam (approx. 30 min).

Prerequisites
none

Competence Goal
By the end of the course, students will

- know the basic concepts of mathematical statistics,
- be able to apply them independently to simple problems and examples,
- know specific probabilistic techniques and be able to use them for the mathematical analysis of estimation and test procedures,
- know the asymptotic behavior of maximum likelihood estimators and the generalized likelihood ratio for parametric test problems.

Content
The course covers basic concepts of mathematical statistics, in particular the finite optimality theory of estimators and tests, and the asymptotic behavior of estimators and test statistics. Topics are:

- Optimal and best linear unbiased estimators,
- Cramér-Rao bound in exponential families,
- sufficiency, completeness and the Lehmann-Scheffé theorem,
- the multivariate normal distribution,
- convergence in distribution and multivariate central limit theorem,
- Glivenko-Cantelli theorem,
- limit theorems for U-statistics,
- asymptotic estimation theory (maximum likelihood estimator),
- asymptotic relative efficiency of estimators,
- Neyman-Pearson tests and optimal unbiased tests,
- asymptotic tests in parametric models (likelihood ratio tests).

Module grade calculation
The module grade is the grade of the oral exam.
**Workload**
Total workload: 240 hours

**Attendance:** 90 hours
- lectures, problem classes, and examination

**Self-studies:** 150 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

**Recommendation**
The contents of the courses "Probability theory" and "Statistics" are strongly recommended.
3.126 Module: Mathematical Topics in Kinetic Theory [M-MATH-104059]

**Responsible:** Prof. Dr. Dirk Hundertmark

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

**Mandatory**

<table>
<thead>
<tr>
<th>Credits</th>
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<th>Duration</th>
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<td>1 term</td>
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</table>

**Prerequisites**
None

**Competence Goal**
The students are familiar with the basic questions in kinetic theory and methodical approaches to their solutions. With the acquired knowledge they are able to understand the required analytical methods and are able to apply them to the basic equations in kinetic theory.

**Content**

- Boltzmann equation: Cauchy problem and properties of solutions
- entropy and H theorem
- equilibrium and convergence to equilibrium
- other models of kinetic theory
### 3.127 Module: Maxwell's Equations [M-MATH-102885]

**Responsible:** PD Dr. Frank Hettlich  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Analysis  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Analysis  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
- Additional Examinations

<table>
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<th>Recurrence</th>
<th>Duration</th>
<th>Level</th>
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<tr>
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**Mandatory**

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<thead>
<tr>
<th>T-MATH-105856</th>
<th>Maxwell's Equations</th>
<th>8 CR</th>
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</thead>
</table>

**Competence Certificate**  
The module will be completed by an oral exam (~30min.).

**Prerequisites**  
none

**Competence Goal**  
The students can explain mathematical questions from the theory of Maxwell's equations. They can formulate and prove the main theorems on properties and existence of solutions, can apply these to specific cases, and can compare results with simpler differential equations (like the Helmholtz equation).

**Content**  
Specific examples of solutions to Maxwell's equations, properties of solutions (e.g. representation theorems), specific cases like E-mode and H-mode, corresponding boundary value problems.

**Module grade calculation**  
The module grade is the grade of the oral exam

**Workload**  
Total workload: 240h  
Attendence: 90h  
- lecture, problem class, examination  
Self-studies: 150h  
- follow-up and deepening of the course content  
- work on problem sheets  
- literature study and internet research related to the course content  
- preparation of the course content

**Recommendation**  
Desirable is basic knowledge from functional analysis
### 3.128 Module: Medical Imaging Technology II [M-ETIT-106670]

**Responsible:** Prof. Dr.-Ing. Maria Francesca Spadea  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Complementary Field / Subject Electrical Engineering

<table>
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<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
<th>Level</th>
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**Mandatory**

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<th>Course Title</th>
<th>Credits</th>
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<tr>
<td>T-ETIT-113421</td>
<td>Medical Imaging Technology II</td>
<td>3 CR</td>
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</tbody>
</table>

**Competence Certificate**  
The examination takes place in form of a written examination lasting 90 minutes.

**Prerequisites**  
none

**Competence Goal**  
For each imaging modality students will be able to:

- identify required energy source;
- analyze the interactions between the form of energy and biological tissue;
- distinguishing desired signal from noise contribution;
- critically interpret the image content to derive knowledge;
- evaluate image quality and implementing strategies to improve it.

Moreover, the student will be able to communicate in technical and clinical English language.

**Content**  
- the basic knowledge of mathematical and physical principles of medical imaging formation, including nuclear medicine imaging and magnetic resonance imaging.
- the component of medical imaging devices.
- assessment of image quality in terms of signal-to-noise-ratio, presence of artifact, spatial, spectral and temporal resolution.
- safety and protection for patients and workers.

**Module grade calculation**  
The module grade is the grade of the written exam.

**Workload**

- attendance in class: 15*2h = 30h
- preparation / follow-up: 15*2h = 30h
- exam preparation / attendance: 30h = 90h

A total of 90h = 3 CR

**Recommendation**

- Basic knowledge in the field of physics and signal processing is helpful.
- The contents of the module "Medical Imaging Technology I" are recommended.
3.129 Module: Methodical Foundations of OR (M-WIWI-101414)

**Responsible:** Prof. Dr. Oliver Stein

**Organisation:** KIT Department of Economics and Management

**Part of:** Complementary Field / Subject Economics

<table>
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<tr>
<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Duration</th>
<th>Level</th>
<th>Version</th>
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**Compulsory Elective Courses (Election: at least 1 item as well as between 4,5 and 9 credits)**

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<th>Course Name</th>
<th>Credits</th>
<th>Lecturer</th>
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<tbody>
<tr>
<td>T-WIWI-102726</td>
<td>Global Optimization I</td>
<td>4,5 CR</td>
<td>Stein</td>
</tr>
<tr>
<td>T-WIWI-103638</td>
<td>Global Optimization I and II</td>
<td>9 CR</td>
<td>Stein</td>
</tr>
<tr>
<td>T-WIWI-102724</td>
<td>Nonlinear Optimization I</td>
<td>4,5 CR</td>
<td>Stein</td>
</tr>
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<td>T-WIWI-103637</td>
<td>Nonlinear Optimization I and II</td>
<td>9 CR</td>
<td>Stein</td>
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**Supplementary Courses (Election: )**

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<th>Lecturer</th>
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<td>Introduction to Stochastic Optimization</td>
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<td>Rebennack</td>
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<td>T-WIWI-102727</td>
<td>Global Optimization II</td>
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<td>Stein</td>
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<td>T-WIWI-102725</td>
<td>Nonlinear Optimization II</td>
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<td>T-WIWI-102704</td>
<td>Facility Location and Strategic Supply Chain Management</td>
<td>4,5 CR</td>
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</table>

**Competence Certificate**

The assessment is carried out as partial written exams (according to Section 4(2), 1 of the examination regulation) of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module. The assessment procedures are described for each course of the module separately.

The overall grade of the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

**Prerequisites**

At least one of the courses Nonlinear Optimization I [2550111] and Global Optimization I [2550134] has to be examined.

**Competence Goal**

The student

- names and describes basic notions for optimization methods, in particular from nonlinear and from global optimization,
- knows the indispensable methods and models for quantitative analysis,
- models and classifies optimization problems and chooses the appropriate solution methods to solve also challenging optimization problems independently and, if necessary, with the aid of a computer,
- validates, illustrates and interprets the obtained solutions.

**Content**

The module focuses on theoretical foundations as well as solution algorithms for optimization problems with continuous decision variables. The lectures on nonlinear programming deal with local solution concepts, whereas the lectures on global optimization treat approaches for global solutions.

**Annotation**

The planned lectures and courses for the next three years are announced online (http://www.ior.kit.edu).

**Workload**

The total workload for this module is approx. 270 hours (9 credits). The allocation is based on the credit points of the courses in the module.

The total number of hours per course results from the time required to attend the lectures and exercises, as well as the examination times and the time required to achieve the learning objectives of the module for an average student for an average performance.

**Recommendation**

The courses Introduction to Operations Research I and II are helpful.
**3.130 Module: Methods of Signal Processing [M-ETIT-100540]**

**Responsible:** Prof. Dr.-Ing. Michael Heizmann  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Complementary Field / Subject Electrical Engineering

<table>
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<tr>
<th>Credits</th>
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</table>

**Mandatory**

| T-ETIT-100694 | Methods of Signal Processing | 6 CR | Heizmann |

**Prerequisites**

none
3.131 Module: Metric Geometry [M-MATH-105931]

**Responsible:** Prof. Dr. Alexander Lytchak  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Complementary Field / Field Algebra and Geometry  
- Mathematical Specialization  
- Additional Examinations

<table>
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**Mandatory**

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<th>Course Title</th>
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<tr>
<td>T-MATH-111933</td>
<td>Metric Geometry</td>
<td>8</td>
<td>CR</td>
<td>Lytchak, Nepechiy</td>
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</table>

**Competence Certificate**

oral examination of circa 20 minutes

**Prerequisites**

None

**Module grade calculation**

The module grade is the grade of the final oral exam.
3.132 Module: Microeconomic Theory [M-WIWI-101500]

**Responsible:** Prof. Dr. Clemens Puppe  
**Organisation:** KIT Department of Economics and Management  
**Part of:** Complementary Field / Subject Economics

<table>
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<th>Credits</th>
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<th>Recurrence</th>
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<td>Each term</td>
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**Compulsory Elective Courses (Election: at least 9 credits)**

<table>
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<tr>
<th>Course Code</th>
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<th>Credits</th>
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<td>T-WIWI-102861</td>
<td>Advanced Game Theory</td>
<td>4,5 CR</td>
<td>Ehrhart, Puppe, Reiß</td>
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<td>Auction Theory</td>
<td>4,5 CR</td>
<td>Ehrhart</td>
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<td>T-WIWI-105781</td>
<td>Incentives in Organizations</td>
<td>4,5 CR</td>
<td>Nieken</td>
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<td>T-WIWI-113264</td>
<td>Matching Theory</td>
<td>4,5 CR</td>
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<td>T-WIWI-102859</td>
<td>Social Choice Theory</td>
<td>4,5 CR</td>
<td>Puppe</td>
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</table>

**Competence Certificate**

The assessment is carried out as partial exams (according to Section 4(2), 1 or 2 of the examination regulation) of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module. The assessment procedures are described for each course of the module separately.

The overall grade of the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

**Prerequisites**

None

**Competence Goal**

Students are able to model practical microeconomic problems mathematically and to analyze them with respect to positive and normative questions, understand individual incentives and social outcomes of different institutional designs.

Here is an example of a positive question: what firm decisions does a specific regulatory policy result in under imperfect competition? An example of a normative question would be: which voting rule has appealing properties?

**Content**

The module teaches advanced concepts and content in microeconomic theory. Thematically, it offers a formally rigorous treatment of game theory and exemplary applications, such as strategic interaction on markets and non-/cooperative bargaining ("Advanced Game Theory"), as well as specialized courses dedicated to auctions ("Auktionstheorie") and incentive systems in organizations ("Incentives in Organizations"). Moreover, it offers the opportunity to delve deeper into the mathematical theory of voting and collective decision making, i.e. the systematic aggregation of preferences and judgments ("Social Choice Theory").

**Workload**

Total workload for 9 credit points: approx. 270 hours

The exact distribution is based on the credit points of the courses in the module.
Module: Minimal Surfaces [M-MATH-106666]

### Responsible
Dr. Peter Lewintan

### Organisation
KIT Department of Mathematics

### Part of
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

### Credits
3

### Grading scale
Grade to a tenth

### Recurrence
Irregular

### Duration
1 term

### Language
German

### Level
4

### Version
1

### Mandatory
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<th>Content</th>
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<tbody>
<tr>
<td>3</td>
<td>Minimal Surfaces</td>
</tr>
</tbody>
</table>

### Competence Certificate
The module will be completed by an oral exam (about 30 min).

### Prerequisites
None

### Competence Goal
Graduates
- are able to mathematically understand and solve a practical problem;
- can explain important results of the theory of minimal surfaces and apply them to examples;
- are prepared to write a thesis in the field of the theory of minimal surfaces or the calculus of variations.

### Content
Minimal surfaces are critical points of the area functional and locally minimize its area. They can also be described by having zero mean curvature. In this course we consider two dimensional minimal surfaces in $\mathbb{R}^3$ and discuss their properties. We will use arguments from differential geometry, the calculus of variations, the theory of partial differential equations and functions of a complex variable. Our goal is to prove the classical Plateau's problem.

### Module grade calculation
The module grade is the grade of the oral exam.

### Workload
Total workload: 90 hours

- **Attendance:** 30 hours
  - lectures, problem classes, and examination

- **Self-studies:** 60 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

### Recommendation
The course "Classical Methods for Partial Differential Equations" is recommended.
### 3.134 Module: Modelling and Simulation of Lithium-Ion Batteries [M-MATH-106640]

**Responsible:** Prof. Dr. Willy Dörfler  
**Organisation:** KIT Department of Mathematics

**Part of:**  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
- Additional Examinations

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<tr>
<td>T-MATH-113382</td>
<td>Modelling and Simulation of Lithium-Ion Batteries</td>
<td>4 CR</td>
</tr>
</tbody>
</table>

**Competence Certificate**  
oral exam of ca. 20 minutes

**Prerequisites**  
None

**Competence Goal**  
Participants know about the modelling and physical basics that lead to the model equations. They can explain (at least for simplified problems) their well-posedness. They are able to analyze stability and convergence of the presented methods.

**Content**

- Derivation of the model equations,  
- Existence for simplified model problems,  
- Discretization of the initial boundary value problems with finite elements,  
- Nonlinear diffusion equations, Cahn-Hilliard equation, linear elasticity and contact problems,  
- Stability and convergence of the discrete models,  
- Applications

**Module grade calculation**  
The grade of the module is the grade of the oral exam.

**Workload**  
Total workload: 120 hours  
Attendance: 45 h  
- lectures, problem classes and examination  
Self studies: 75 h  
- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research on the course content,  
- preparation for the module examination

**Recommendation**  
Basic knowledge in the numerical treatment of differential equations, such as boundary value problems or initial value problems is strongly recommended.
3.135 Module: Models of Mathematical Physics [M-MATH-102875]

| Responsible: | Prof. Dr. Wolfgang Reichel |
| Organisation: | KIT Department of Mathematics |

Part of:
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

| Credits | 8 |
| Grading scale | Grade to a tenth |
| Recurrence | Irregular |
| Duration | 1 term |
| Level | 4 |
| Version | 1 |

Mandatory

| T-MATH-105846 | Models of Mathematical Physics | 8 CR |
| Hundertmark, Plum, Reichel |

Competence Certificate
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
None

Competence Goal
Graduates will be able to

- understand the modeling of fundamental physical effects,
- understand the most important mathematical properties of these differential equation models,
- calculate exemplary solutions,
- draw conclusions regarding the models from the provable properties of the differential equations and the solutions.

Content

- Reaction-diffusion models
- Wave phenomena
- Maxwell equations and electrodynamics
- Schrödinger equation and quantum mechanics
- Navier-Stokes equation and fluid dynamics
- Elasticity
- Surface tension

Module grade calculation
The module grade is the grade of the oral/written exam.

Workload
Total workload: 240 hours

Attendance: 90 hours
- lectures, problem classes, and examination

Self-studies: 150 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination
# Module: Modern Experimental Physics I, Atoms, Nuclei and Molecules [M-PHYS-106331]

**Responsible:** Studiendekan Physik  
**Organisation:** KIT Department of Physics  
**Part of:** Complementary Field / Subject Physics

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<td>Recurrence</td>
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<tbody>
<tr>
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<td>Modern Experimental Physics I, Atoms, Nuclei and Molecules</td>
<td>8 CR</td>
<td>Studiendekan Physik</td>
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</tbody>
</table>

**Competence Certificate**  
See components of this module

**Prerequisites**  
none
Module: Modern Experimental Physics II, Structure of Matter [M-PHYS-106332]

**Responsible:** Studiendekan Physik

**Organisation:** KIT Department of Physics

**Part of:** Complementary Field / Subject Physics

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</table>

**Mandatory**

| T-PHYS-112847 | Modern Experimental Physics II, Structure of Matter | 8 CR | Studiendekan Physik |

**Competence Certificate**

See components of this module

**Prerequisites**

none
Module: Modern Theoretical Physics I, Foundations of Quantum Mechanics [M-PHYS-106334]

**Responsible:** Studiendekan Physik

**Organisation:** KIT Department of Physics

**Part of:** Complementary Field / Subject Physics

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</table>

**Mandatory**

| CR | T-PHYS-112848 | Modern Theoretical Physics I, Foundations of Quantum Mechanics | 8 CR |

Competence Certificate

oral exam, ca. 45 Minuten

**Prerequisites**

none

**Competence Goal**

The student learns the basic concepts of single-particle quantum mechanics and applies them to important questions. He / she lays the foundation for a fundamental understanding of the microscopic world.

**Content**

- Introduction: Historical Remarks, Limitations of Classical Physics
- Dualism particle and wave: wave mechanics, matter waves, wave packets, uncertainty principle, Schrödinger equation, qualitative understanding of simple cases.
- Mathematical tools: Hilbert space, Bra and Ket, operators, hermiticity, unitarity, eigenvectors and eigenvalues, observable, basis, completeness.
- Postulates of quantum mechanics: measurement process, time evolution, time evolution of expectation values, Ehrenfest theorem and classical limit.
- One-dimensional potentials: Potential wells, harmonic oscillator.
- Bound states in a three-dimensional potential: separation of variables, central potential, angular momentum, rotational symmetry and spin, degeneracy, particles in the external electromagnetic field, hydrogen atom.
- Quantum Information
- Particles in the external electromagnetic field.
- Time-independent perturbation theory: non-degenerate and degenerate case, fine structure of hydrogen spectrum, Stark effect.

**Workload**

240 hours composed of active time (90), wrap-up of the lecture incl. preparation of the exercises and the exam (150)

**Literature**

Textbooks on Quantum Mechanics
Module: Modern Theoretical Physics II, Advanced Quantum Mechanics and Statistical Physics [M-PHYS-106335]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Complementary Field / Subject Physics

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</table>

Mandatory

| T-PHYS-112849 | Modern Theoretical Physics II, Advanced Quantum Mechanics and Statistical Physics | 8 CR | Studiendekan Physik |

Competence Certificate
See components of this module

Prerequisites
none
# Module: Modular Forms [M-MATH-102868]

**Responsible:** PD Dr. Stefan Kühnlein  
**Organisation:** KIT Department of Mathematics  
**Part of:** Mathematical Methods 1 / Field Algebra and Geometry  
Mathematical Methods 2 / Field Algebra and Geometry  
Complementary Field / Field Algebra and Geometry  
Mathematical Specialization  
Additional Examinations  

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<th>Grading scale</th>
<th>Recurrence</th>
<th>Duration</th>
<th>Level</th>
<th>Version</th>
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</table>

## Mandatory

| T-MATH-105843 | Modular Forms | 8 CR | Kühnlein |

### Competence Certificate

The exam is an oral exam of about 30 minutes.

### Prerequisites

None

### Competence Goal

Participants are able to

- understand basic questions discussed in the theory of modular forms
- see the relevance of analytic results for solving certain arithmetic problems
- start reading a recent research paper and write a thesis in the area of modular forms.

### Content

- Modular Group: Upper half plane, Mobius transforms, fundamental regions, Eisenstein series, modular forms, dimension formula
- congruence subgroups: Petersson scalar product, Hecke operators, Atkin-Lehner-theory of new forms
- L-series: Mellin transform, functional equation, Euler product decomposition of the L-series of a Hecke-eigenform

### Module grade calculation

Grade of the oral exam

### Workload

Total workload: 240 hours  
Attendance: 90 hours  
- lectures, problem classe and examination  
Self studies: 150 hours  
- follow-up and deepening of the course content  
- work on problem sheets  
- literature study and internet research on the course content  
- preparation for the module examination

### Recommendation

The basic notions of algebra and number theory should be well-understood, and also basic principles of complex analysis.
3.141 Module: Monotonicity Methods in Analysis [M-MATH-102887]

**Responsible:** PD Dr. Gerd Herzog

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

### Credits | Grading scale | Recurrence | Duration | Level | Version
--- | --- | --- | --- | --- | ---
3 | Grade to a tenth | Irregular | 1 term | 4 | 1

### Mandatory
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<tr>
<td>3</td>
<td>Monotonicity Methods in Analysis</td>
<td></td>
<td>3 CR</td>
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</table>

**Competence Certificate**
The module will be completed by an oral exam (about 20 min).

**Prerequisites**
None

**Competence Goal**
At the end of the course, students can

- name, discuss and apply basic techniques of the order-theoretical methods of analysis,
- apply specific order theory techniques to fixed point problems and differential equations.

**Content**

- Fixed point theorems in ordered sets and ordered metric spaces.
- Ordered Banach spaces.
- Quasimonotone increasing functions.
- Differential equations and differential inequalities in ordered Banach spaces.

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 90 hours
Attendance: 30 hours
- lectures, problem classes, and examination
Self-studies: 60 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

**Recommendation**
The course "Functional Analysis" is recommended.
3.142 Module: Multigrid and Domain Decomposition Methods [M-MATH-102898]

**Responsible:** Prof. Dr. Christian Wieners

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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</table>

**Mandatory**

| | T-MATH-105863 | Multigrid and Domain Decomposition Methods | 4 CR | Wieners |

**Prerequisites**

none

**Competence Goal**

The students became acquainted with multigrid and domain decomposition methods. They learn algorithms, results on convergence, and representative applications.

**Content**

- The two-grid method
- Classical multigrid theory
- Additive subspace correction method
- Multiplicative subspace correction method
- Multigrid methods for saddle point problems

**Responsible:** Prof. Dr. Martina Zitterbart  
**Organisation:** KIT Department of Informatics  
**Part of:** Complementary Field / Subject Computer Science

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<td>German</td>
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**Mandatory**

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Mathematics Master 2016 (Master of Science (M.Sc.))  
Module Handbook as of 09/07/2024
### 3.144 Module: Nonlinear Analysis [M-MATH-103539]

**Responsible:** Prof. Dr. Tobias Lamm  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 2 / Field Analysis  
- Complementary Field / Field Analysis  
- Mathematical Specialization  
- Additional Examinations

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</table>

**Prerequisites**  
None
3.145 Module: Nonlinear Control Systems [M-ETIT-100371]

**Responsible:** Prof. Dr.-Ing. Sören Hohmann

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** Complementary Field / Subject Electrical Engineering

**Credits** 3

**Grading scale** Grade to a tenth

**Recurrence** Each summer term

**Duration** 1 term

**Language** German

**Level** 4

**Version** 1

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<td>Each summer term</td>
<td>German</td>
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</table>

**Prerequisites**

none
Module: Nonlinear Evolution Equations [M-MATH-102877]

**Responsible:** Prof. Dr. Roland Schnaubelt

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

**Credits:** 8

**Grading scale:** Grade to a tenth

**Recurrence:** Irregular

**Duration:** 1 term

**Language:** German/English

**Level:** 4

**Version:** 1

**Mandatory**

| T-MATH-105848 | Nonlinear Evolution Equations | 8 CR | Frey, Schnaubelt |

**Competence Certificate**
The module will be completed by an oral exam (ca. 30 min).

**Prerequisites**
None

**Competence Goal**
Students can explain the well-posedness theory of semilinear evolution equations in the locally Lipschitz case and apply it to cubic wave equations in 3D. They can also examine these for global existence and blow-up. Based on the fundamentals of interpolation theory for generators, they can also deal with more general nonlinearities in the parabolic case. In this case, they can determine the long-term behavior with the help of Lyapunov functions and the principle of linearized stability, and apply these results to reaction-diffusion systems. They can derive basic Strichartz inequalities. They can use them to treat the well-posedness and long-term behavior of the nonlinear Schrödinger and wave equations. They master the important proof techniques in the theory of semilinear evolution equations and can at least sketch more complex proofs.

**Content**
- semilinear evolution equations
- wellposedness, global existence versus blow-up
- interpolation theory for generators
- Lyapunov functions, linearized stability
- reaction diffusion systems
- semilinear wave and Schrödinger equations
- Strichartz inequalities

**Module grade calculation**
The grade of the module is the grade of the oral exam.

**Workload**
Total workload: 240 hours

- Attendance: 90 h
  - lectures, problem classes and examination

- Self studies: 150 h
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research on the course content,
  - preparation for the module examination

**Recommendation**
The contents of the modules Functional Analysis and Evolution Equations are strongly recommended. However, the relevant parts of Evolution Equations will be briefly recalled.
**3.147 Module: Nonlinear Functional Analysis [M-MATH-102886]**

**Responsible:** PD Dr. Gerd Herzog  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 2 / Field Analysis  
- Complementary Field / Field Analysis  
- Mathematical Specialization  
- Additional Examinations

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<td>Grade to a tenth</td>
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<td>1 term</td>
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</table>

### Competence Certificate

The module will be completed by an oral exam (about 20 min).

### Prerequisites

None

### Competence Goal

At the end of the course, students can

- name, discuss and apply basic techniques of nonlinear functional analysis,  
- explain the construction of the Brouwer- and Schauder-degree,  
- apply specific techniques of degree theory to nonlinear problems.

### Content

- The Brouwer degree and its applications  
- The Leray-Schauder degree and its applications  
- Odd mappings  
- Measures of non-compactness and their applications

### Module grade calculation

The module grade is the grade of the oral exam.

### Workload

**Total workload:** 90 hours  
**Attendance:** 30 hours  
- lectures, problem classes, and examination  
**Self-studies:** 60 hours  
- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research relating to the course content,  
- preparation for the module examination
3.148 Module: Nonlinear Maxwell Equations [M-MATH-105066]

**Responsible:** Prof. Dr. Roland Schnaubelt

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

| T-MATH-110283 | Nonlinear Maxwell Equations | 8 CR | Schnaubelt |

**Competence Certificate**
The module will be completed by an oral exam (ca. 30 min).

**Prerequisites**
none

**Competence Goal**
Students can explain some basic types of nonlinear Maxwell equations and the physical significance of the variables that occur. They are able to prove and discuss local wellposedness theorems in the whole space using energy methods. They can derive Strichartz inequalities for linear Maxwell equations. With their help, they can show improved wellposedness results.

**Content**
- Maxwell equations with nonlinear material laws
- local wellposedness theory in the whole space using linearisation, apriori estimates and regularisation
- Strichartz inequalities and improved wellposedness theory

**Module grade calculation**
The grade of the module is the grade of the oral exam.

**Workload**
Total workload: 240 hours

- **Attendance:** 90 h
  - lectures, problem classes and examination

- **Self studies:** 150 h
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research on the course content,
  - preparation for the module examination

**Recommendation**
The contents of the module "Functional Analysis" are strongly recommended.
3.149 Module: Nonlinear Schroedinger and Wave Equations [M-MATH-103086]

**Responsible:** Prof. Dr. Lutz Weis

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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<td>Nonlinear Schroedinger and Wave Equations</td>
<td>8 CR</td>
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</table>
3.150 Module: Nonlinear Wave Equations [M-MATH-105326]

**Responsible:** Prof. Dr. Wolfgang Reichel  
Prof. Dr. Roland Schnaubelt

**Organisation:** KIT Department of Mathematics

**Part of:** Mathematical Methods 1 / Field Analysis  
Mathematical Methods 2 / Field Analysis  
Complementary Field / Field Analysis  
Mathematical Specialization  
Additional Examinations

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**Mandatory**

| T-MATH-110806 | Nonlinear Wave Equations | 4 CR | Reichel, Schnaubelt |

**Competence Certificate**
The module will be completed by an oral exam (ca. 20 min).

**Prerequisites**
None

**Competence Goal**
Graduates will be able to

- name important properties of nonlinear wave equations,
- describe essential difficulties in the analysis of the initial value problem,
- analyze the short- and long-term behavior of solutions of semilinear wave equations using modern techniques.

**Content**
The aim of the course is an introduction to methods for analyzing nonlinear wave equations. The aim is to get to know the basics of various important techniques and to apply them to simple models. The following topics will be covered:

- Symmetries and conservation laws
- Fourier transformation, Sobolev spaces
- Energy estimates
- Strichartz estimates
- Local and global well-posedness results
- Vector field methods
- Longtime behavior

**Module grade calculation**
The grade of the module is the grade of the oral exam.

**Workload**
Total workload: 120 hours

**Attendance:** 45 h

- lectures, problem classes and examination

**Self studies:** 75 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination
Recommendation
The contents of the module "Functional Analysis" are strongly recommended.
### Module: Nonparametric Statistics [M-MATH-102910]

**Responsible:** PD Dr. Bernhard Klar  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Stochastics  
- Mathematical Methods 2 / Field Stochastics  
- Complementary Field / Field Stochastics  
- Mathematical Specialization  
- Additional Examinations

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<tr>
<td>T-MATH-105873</td>
<td>Nonparametric Statistics</td>
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</table>

**Competence Certificate**

The module will be completed with an oral exam (ca. 20 min).

**Prerequisites**

None

**Competence Goal**

By the end of the course, students will be able to

- explain nonparametric statistical tests based on location problems and distinguish them from parametric methods,
- name and explain nonparametric estimation methods for nonparametric regression and density estimation,
- know and apply optimality criteria for the statistical methods covered.

**Content**

- Introduction to nonparametric models  
- Nonparametric tests, especially rank statistics  
- Nonparametric density and regression estimation  
- Dependence measures or optimal convergence rates

**Module grade calculation**

The module grade is the grade of the oral exam.

**Workload**

Total workload: 120 hours  
Attendance: 45 h

- lectures, problem classes and examination

Self studies: 75 h

- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research on the course content,  
- preparation for the module examination

**Recommendation**

The contents of the module 'Probability Theory' are strongly recommended. The module 'Mathematical Statistics' is recommended.
3.152 Module: Numerical Analysis of Helmholtz Problems [M-MATH-105764]

Responsible: TT-Prof. Dr. Barbara Verfürth
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

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Mandatory

| T-MATH-111514 | Numerical Analysis of Helmholtz Problems | 3 CR | Verfürth |

Competence Certificate
oral examination of circa 30 minutes

Prerequisites
none

Module grade calculation
The module grade is the grade of the final oral exam.
Module: Numerical Analysis of Neural Networks [M-MATH-106695]

Responsible: TT-Prof. Dr. Roland Maier
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

Credits: 6
Grading scale: Grade to a tenth
Recurrence: Irregular
Duration: 1 term
Language: German/English
Level: 4
Version: 1

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<td>T-MATH-113470</td>
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Competence Certificate
The module will be completed by an oral exam (about 30 min).

Prerequisites
None.

Competence Goal
The goal of the lecture is to provide a mathematical foundation of neural networks from the perspective of numerical analysis. Students know basic definitions and terminology as well as classical approximation results for neural networks. They are familiar with numerical methods for the efficient training of neural networks and can analyze them. Moreover, students can apply the concepts to popular applications (such as physics-informed neural networks, Deep Ritz method, etc.).

Content

- Neural networks
- Approximation results
- Connections to finite element methods
- Numerical methods for the efficient learning
- Datasets

Module grade calculation
The grade of the module is the grade of the oral exam.

Annotation
The course is offered in English. If everybody speaks German, the lecture will be held in German.

Workload
Total workload: 180 hours
Attendance: 60 h

- lectures, problem classes and examination

Self studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendation
Basic knowledge of ordinary and/or partial differential equations as well as the contents of the module "Numerical Methods for Differential Equations" are recommended. Basic knowledge of functional analysis and finite element methods is helpful, but not required.
3.154 Module: Numerical Complex Analysis [M-MATH-106063]

Responsible: Prof. Dr. Marlis Hochbruck
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

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Competence Certificate
Oral exam of approximately 20 minutes.

Prerequisites
None.

Competence Goal
Graduates

- can apply techniques and concepts from complex analysis in numerical analysis,
- are prepared to write a thesis in numerical analysis.

Content
In this lecture we consider numerical methods for problems in complex analysis and complex analysis techniques to analyze numerical methods. It provides the chance to rediscover theorems known from the complex analysis lecture in applications.
The following topics are planned

- Calculations with power series: formal Newton's method and FFT,
- control systems and convolution quadrature (Cauchy integral formula, Laplace transform, argument principle),
- rational approximation to the exponential: order stars (maximum principle, argument principle),
- convergence of iterative methods for linear systems of equations an approximation of the matrix exponential operator (conformal mappings, Cauchy integral formula),
- numerical conformal mapping.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 h
Attendance: 60 h
- lectures, problem classes, and examination
Self-studies: 120 h
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination.

Recommendation
Basic knowledge of complex analysis is highly recommended.

Literature
Lecture notes with references.

**Responsible:** Prof. Dr. Hartwig Anzt

**Organisation:** KIT Department of Mathematics

**Part of:** Mathematical Methods 1 / Field Applied and Numerical Mathematics  
Mathematical Methods 2 / Field Applied and Numerical Mathematics  
Complementary Field / Field Applied and Numerical Mathematics  
Mathematical Specialization  
Additional Examinations

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</table>

**Mandatory**

T-MATH-107497  
Numerical Linear Algebra for Scientific High Performance Computing  
5 CR  
Anzt

**Prerequisites**

None
### Module: Numerical Linear Algebra in Image Processing [M-MATH-104058]

**Responsible:** PD Dr. Volker Grimm  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
**Credits:** 6  
**Grading scale:** Grade to a tenth  
**Recurrence:** Irregular  
**Duration:** 1 term  
**Level:** 4  
**Version:** 1

| Mandatory | T-MATH-108402 | Numerical Linear Algebra in Image Processing | 6 CR | Grimm |

**Competence Certificate**  
The module will be completed by an oral exam (ca. 20 min).

**Prerequisites**  
None

**Competence Goal**  
Graduates can name essential concepts of image processing using numerical linear algebra methods and implement them efficiently.

**Content**  
- Linear models of optical devices  
- Point spread function and discrete convolution  
- Structured matrices and fast transformations  
- Large, ill-conditioned linear systems of equations  
- Krylov subspace methods, preconditioning  
- Several applications

**Module grade calculation**  
The module grade is the grade of the oral exam.

**Workload**  
Total workload: 180 hours  
**Attendance:** 60 hours  
- lectures, problem classes, and examination  
**Self-studies:** 120 hours  
- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research relating to the course content,  
- preparation for the module examination
Module: Numerical Methods for Differential Equations [M-MATH-102888]


Responsible: Prof. Dr. Willy Dörfler
Prof. Dr. Tobias Jahnke

Organisation: KIT Department of Mathematics

Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

Credits 8
Grading scale Grade to a tenth
Recurrence Each winter term
Duration 1 term
Level 4
Version 1

Mandatory

Competence Certificate
The module will be completed by a written exam (120 min).

Prerequisites
None

Competence Goal
At the end of the course, students

- know important examples of numerical methods for ordinary differential equations as well as the underlying construction principles
- are able to analyze the properties of these methods (in particular their stability, convergence and complexity)
- are able to analyze basic numerical methods for linear partial differential equations
- can explain concepts of modelling with differential equations

Content
- Numerical methods for initial value problems (Runge-Kutta methods, multistep methods, order, stability, stiff problems)
- Numerical methods for boundary value problems (finite difference methods for second-order elliptic equations)
- Numerical methods for initial boundary value problems (finite difference methods for parabolic equations and hyperbolic equations)

Module grade calculation
The module grade is the grade of the written exam.

Workload
Total workload: 240 hours

Attendance: 90 hours
- lectures, problem classes, and examination

Self-studies: 150 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination
Recommendation
It is highly recommended that participants have completed the modules "Numerische Mathematik 1 und 2" as well as "Programmieren: Einstieg in die Informatik und algorithmische Mathematik".
Module: Numerical Methods for Hyperbolic Equations [M-MATH-102915]

3.158 Module: Numerical Methods for Hyperbolic Equations [M-MATH-102915]

**Responsible:** Prof. Dr. Willy Dörfler

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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**Prerequisites**
none

**Competence Goal**
.
Module: Numerical Methods for Integral Equations [M-MATH-102930]

Responsible: PD Dr. Tilo Arens
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

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Mandatory

| T-MATH-105901 | Numerical Methods for Integral Equations | 8 CR | Arens, Hettlich |

Competence Certificate
The module examination is carried out by one oral examination (approx. 30 minutes).

By successfully participating in the problem classes by correctly completing 60% of the programming exercise assignments, students will obtain a bonus to the grade of the oral examination. This bonus amounts to an improvement of the grade to the next marking step (a decrease by 0.3 or 0.4, respectively), if the original grade is between 4.0 and 1.3.

Prerequisites
None

Competence Goal
Students are able to name and describe basic methods for numerically solving linear integral equations of the second kind, such as the Nyström method, collocation method and Galerkin method, as well as their underlying principles such as interpolation and numerical integration. They are able to apply these methods for numerically solving integral equations and to implement concrete examples on a computer. Students are able to state convergence results concerning these methods and have mastered the application of methods of proof for such results. They can independently derive corresponding results for simple variations of these methods and perform the analysis of the convergence behavior for specific applications.

Content
- Boundary integral operators
- Interpolation and quadrature formulae
- Nyström methods
- Projection methods and boundary element methods

Module grade calculation
The grade of the module is the grade of the oral examination, modified by the bonus from the problem class assignments.

Workload
Total workload: 240 hours

Attendance: 90 h
- lectures, problem classes and examination

Self studies: 150 h
- increased understanding of module content by wrapping up lectures at home
- work on exercises
- increased understanding of module content by self study of literature and internet research
- preparing for the examination

Recommendation
Numerical Analysis I
Integral Equations
Module: Numerical Methods for Maxwell's Equations [M-MATH-102931]

Responsible: Prof. Dr. Marlis Hochbruck
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

Credits 6
Grading scale Grade to a tenth
Recurrence Irregular
Duration 1 term
Level 4
Version 1

Mandatory
T-MATH-105920 Numerical Methods for Maxwell's Equations 6 CR Hochbruck, Jahnke

Competence Certificate
Oral examination of approximately 20 minutes.

Prerequisites
None.

Competence Goal
The students can interpret the terms arising in the time-dependent Maxwell equations physically and prove the existence and uniqueness of the solution under appropriate assumptions. They know numerical methods and techniques to approximate these solutions and they are able to perform an error analysis. From the practical point of view they are able to evaluate advantages and disadvantages of different methods.

Content
Maxwell equations are a set of vector valued partial differential equations that are fundamental for the propagation of electromagnetic waves in media. In this lecture we start to derive Maxwell equations in integral- and differential form, discuss examples of material laws, boundary conditions, and study the well-posedness in suitable function spaces. For the numerical solution of Maxwell equations, we employ finite element methods for the spatial discretization. Our emphasis is on discontinuous Galerkin methods. Favorable methods for time discretization are splitting methods, (locally) implicit schemes, and exponential integrators. We construct and analyse these methods and discuss their efficient implementation.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 h
Attendance: 60 h
  - lectures, problem classes, and examination
Self-studies: 120 h
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination.

Recommendation
Basic knowledge of ordinary and/or partial differential equations is recommended.
The module "Numerical Methods for Differential Equations" is strongly recommended.

Learning type
Lecture and tutorial with the active contribution of the students; problem sheets every 2 weeks.

Literature
Lecture notes with many references will be provided.
Module: Numerical Methods for Oscillatory Differential Equations [M-MATH-106682]

Responsible: Prof. Dr. Tobias Jahnke
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

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Mandatory
T-MATH-113437 Numerical Methods for Oscillatory Differential Equations 8 CR Jahnke

Competence Certificate
The module will be completed by an oral exam (about 30 min).

Prerequisites
none

Competence Goal
The central topic of the lecture are numerical time-integrators for highly oscillatory ordinary and partial differential equations.

After participation, students
• know selected classes of ordinary and partial differential equations with oscillatory solutions and can explain the reason for the oscillations.
• can explain why time-integration of such problems with traditional methods is usually inefficient.
• know different techniques which can be used to construct more efficient methods for selected problems.
• can explain error bounds for such integrators and know the ideas, techniques and assumptions used in the error analysis.

Content
• Oscillatory ordinary and partial differential equations: examples and applications
• Construction of time integrators
• Oscillations and resonances
• Error analysis
• Space discretization by Fourier collocation methods

Module grade calculation
The grade of the module is the grade of the oral exam.

Annotation
The module will be offered about every second summer semester.

Workload
Total workload: 240 hours
Attendance: 90 h
• lectures, problem classes and examination
Self studies: 150 h
• follow-up and deepening of the course content,
• work on problem sheets,
• literature study and internet research on the course content,
• preparation for the module examination
Recommendation
Participants are expected to be familiar with numerical methods for ordinary differential equations (e.g. Runge-Kutta methods) and with concepts required for their analysis (stability, order, local and global error, etc.).

**Responsible:** Prof. Dr. Marlis Hochbruck

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

### Credits
- **8**

### Grading scale
- Grade to a tenth

### Recurrence
- Irregular

### Duration
- 1 term

### Level
- 4

### Version
- 1

#### Mandatory

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<td>Numerical Methods for Time-Dependent Partial Differential Equations</td>
<td>8 CR</td>
<td>Hochbruck, Jahnke</td>
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#### Competence Certificate

Oral exam of approximately 25 minutes.

#### Prerequisites

None.

#### Competence Goal

Students can analyze numerical methods for abstract evolution equations. They can understand current research results and master various techniques for proving stability and error estimates of time integration methods. They can independently solve exercises, and present and discuss solutions.

#### Content

- Time integration methods for linear, semilinear, and quasilinear evolution equations and their semi-discretization in place, in particular, implicit Runge-Kutta and multistep methods,
- Rigorous error estimates and stability proofs.

#### Module grade calculation

The module grade is the grade of the oral exam.

#### Workload

Total workload: 240 h

- Attendance: 90 h
  - lectures, problem classes, and examination

- Self-studies: 150 h
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination.

#### Recommendation

### M 3.163 Module: Numerical Methods in Computational Electrodynamics [M-MATH-102894]

**Responsible:** Prof. Dr. Willy Dörfler  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
- Additional Examinations

<table>
<thead>
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<th>Duration</th>
<th>Level</th>
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<td>1 term</td>
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</table>

**Mandatory**

| T-MATH-105860 | Numerical Methods in Computational Electrodynamics | 6 CR | Dörfler, Hochbruck, Jahnke, Rieder, Wieners |

**Prerequisites**

none

Responsible: Prof. Dr. Willy Dörfler  
PD Dr. Gudrun Thäter

Organisation: KIT Department of Mathematics

Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics  
Mathematical Methods 2 / Field Applied and Numerical Mathematics  
Complementary Field / Field Applied and Numerical Mathematics  
Mathematical Specialization  
Additional Examinations

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<tr>
<td>T-MATH-105902</td>
<td>4 CR</td>
<td>Numerical Methods in Fluid Mechanics</td>
<td>English</td>
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</table>

Competence Certificate

Oral exam of about 20 minutes.

Prerequisites

None

Competence Goal

Participants know about the modelling and physical basics that lead to the model equations. They know how to discretize fluidmechanical problems with the finite element method and know especially how to treat the incompressibility condition. They are able to analyze stability and convergence of the presented methods.

Content

- Modelling and derivation of the Navier-Stokes equations
- Mathematical and physical representation of energy and stress
- Lax-Milgram theorem, Céa lemma and saddle point theory
- Analytical and numerical treatment of the potential and Stokes flow
- Stability and convergence of the discrete models
- Numerical treatment of the stationary nonlinear equation
- Numerical treatment of the instationary problems
- Applications

Module grade calculation

The grade of the module is the grade of the oral exam.

Workload

Total workload: 120 hours

Attendance: 45 h

- lectures, problem classes and examination.

Self studies: 75 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination.

Recommendation

Basic knowledge in the numerical treatment of differential equations, such as boundary value problems or initial value problems is strongly recommended. Knowledge in functional analysis is recommended.
**Module: Numerical Methods in Mathematical Finance [M-MATH-102901]**

**Responsible:** Prof. Dr. Tobias Jahnke  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
- Additional Examinations

<table>
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<td>T-MATH-105865</td>
<td>Numerical Methods in Mathematical Finance</td>
<td>8 CR</td>
<td>Jahnke</td>
</tr>
</tbody>
</table>

**Competence Certificate**  
oral exam of ca. 30 minutes

**Prerequisites**  
none

**Competence Goal**  
The lecture concentrates on option pricing with numerical methods. After participation, students

- know how to model the price dynamics of different types of options by stochastic or partial differential equations, and to evaluate the differences between these models.  
- know, in particular, the assumptions on which these models are based, which enables them to discuss and question the meaningfulness and reliability of the models.  
- know different methods for solving stochastic and partial differential equations numerically, and for solving high-dimensional integration problems.  
- are able to implement and apply these methods to different types of options, and to analyze their stability and convergence.

**Content**

- Options, arbitrage and other basic concepts,  
- Black-Scholes equation und Black-Scholes formulas,  
- Numerical methods for stochastic differential equations,  
- (Multilevel) Monte Carlo methods,  
- (Quasi-)Monte Carlo integration,  
- Numerical methods for Black-Scholes equations,  
- Numerical methods for American options

**Module grade calculation**  
The grade of the module is the grade of the oral exam.

**Annotation**  
The module is offered every second winter term.
Workload
Total workload: 240 hours
Attendance: 90 h
  • lectures, problem classes and examination
Self studies: 150 h
  • follow-up and deepening of the course content,
  • work on problem sheets,
  • literature study and internet research on the course content,
  • preparation for the module examination

Recommendation
Familiarity with stochastic differential equations, the Ito integral, and the Ito formula is strongly recommended. MATLAB skills are strongly recommended for the programming exercises.
Module: Numerical Optimisation Methods [M-MATH-102892]

**Responsible:** Prof. Dr. Christian Wieners

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

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<tr>
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<td>Numerical Optimisation Methods</td>
<td>8 CR</td>
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</table>

Dörfler, Hochbruck, Jahnke, Rieder, Wieners
Module: Numerical Simulation in Molecular Dynamics [M-MATH-105327]

Responsible: PD Dr. Volker Grimm
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

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Mandatory

| T-MATH-110807 | Numerical Simulation in Molecular Dynamics | 8 CR | Grimm |

Competence Certificate
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
None

Competence Goal
Graduates know the basic concepts for implementing numerical simulations in molecular dynamics on serial and parallel computer architectures. They can name the numerical results and procedures required for simulation in molecular dynamics, apply them to specific problems and implement them.

Content
- Linked-cell method for short-range potentials
- Parallel programming with MPI
- Various potentials and molecules
- Time integration methods
- Aspects of numerical geometric integration
- Methods for the simulation of long-range potentials

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours
Attendance: 90 hours
- lectures, problem classes, and examination
Self-study: 150 hours
- follow-up and deepening of course content,
- work on problem sheets,
- literature study and internet research relating to the course content
- preparation for the module examination

Recommendation
The module M-MATH-102888 (Numerical Methods for Differential Equations) and some programming skills in C (or C++) are recommended.

**Responsible:** Prof. Dr. Stefan Nickel

**Organisation:** KIT Department of Economics and Management

**Part of:** Complementary Field / Subject Economics

**Credits:** 9

**Grading scale:** Grade to a tenth

**Recurrence:** Each term

**Duration:** 2 terms

**Language:** German/English

**Level:** 4

**Version:** 9

**Election notes**

At least one of the courses "Operations Research in Supply Chain Management", "Graph Theory and Advanced Location Models", "Modeling and OR-Software: Advanced Topics" and "Special Topics of Stochastic Optimization (elective)" has to be taken.

Students who choose the module in the field "compulsory elective modules" may select any two courses of the module.

**Compulsory Elective Courses (Election: between 1 and 2 items)**

<table>
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<tr>
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<tr>
<td>T-WIWI-102723</td>
<td>Graph Theory and Advanced Location Models</td>
<td>4,5</td>
<td>Nickel</td>
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<tr>
<td>T-WIWI-106200</td>
<td>Modeling and OR-Software: Advanced Topics</td>
<td>4,5</td>
<td>Nickel</td>
</tr>
<tr>
<td>T-WIWI-102715</td>
<td>Operations Research in Supply Chain Management</td>
<td>4,5</td>
<td>Nickel</td>
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**Supplementary Courses (Election: at most 1 item)**

<table>
<thead>
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<th>Course Title</th>
<th>Credits</th>
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<td>T-MACH-112213</td>
<td>Applied material flow simulation</td>
<td>4,5</td>
<td>Baumann</td>
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<tr>
<td>T-WIWI-106546</td>
<td>Introduction to Stochastic Optimization</td>
<td>4,5</td>
<td>Rebennack</td>
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<td>T-WIWI-102718</td>
<td>Discrete-Event Simulation in Production and Logistics</td>
<td>4,5</td>
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<td>Mixed Integer Programming I</td>
<td>4,5</td>
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<td>T-WIWI-102720</td>
<td>Mixed Integer Programming II</td>
<td>4,5</td>
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<td>Stein</td>
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<td>T-WIWI-112109</td>
<td>Topics in Stochastic Optimization</td>
<td>4,5</td>
<td>Rebennack</td>
</tr>
</tbody>
</table>

**Competence Certificate**

The assessment is carried out as partial exams (according to § 4(2), 1 of the examination regulation) of the single courses of this module, whose sum of credits must meet the minimum requirement of credits of this module.

The assessment procedures are described for each course of the module separately.

The overall grade of the module is the average of the grades for each course weighted by the credits and truncated after the first decimal.

**Prerequisites**

At least one of the courses "Operations Research in Supply Chain Management", "Graph Theory and Advanced Location Models", "Modeling and OR-Software: Advanced Topics" and "Special Topics of Stochastic Optimization (elective)" has to be taken.

**Competence Goal**

The student

- is familiar with basic concepts and terms of Supply Chain Management,
- knows the different areas of SCM and their respective optimization problems,
- is acquainted with classical location problem models (in planes, in networks and discrete) as well as fundamental methods for distribution and transport planning, inventory planning and management,
- is able to model practical problems mathematically and estimate their complexity as well as choose and adapt appropriate solution methods.
Content
Supply Chain Management is concerned with the planning and optimization of the entire, inter-company procurement, production and distribution process for several products taking place between different business partners (suppliers, logistics service providers, dealers). The main goal is to minimize the overall costs while taking into account several constraints including the satisfaction of customer demands.

This module considers several areas of SCM. On the one hand, the determination of optimal locations within a supply chain is addressed. Strategic decisions concerning the location of facilities as production plants, distribution centers or warehouses are of high importance for the rentability of Supply Chains. Thoroughly carried out, location planning tasks allow an efficient flow of materials and lead to lower costs and increased customer service. On the other hand, the planning of material transport in the context of supply chain management represents another focus of this module. By linking transport connections and different facilities, the material source (production plant) is connected with the material sink (customer). For given material flows or shipments, it is considered how to choose the optimal (in terms of minimal costs) distribution and transportation chain from the set of possible logistics chains, which asserts the compliance of delivery times and further constraints. Furthermore, this module offers the possibility to learn about different aspects of the tactical and operational planning level in Supply Chain Management, including methods of scheduling as well as different approaches in procurement and distribution logistics. Finally, issues of warehousing and inventory management will be discussed.

Annotation
Some lectures and courses are offered irregularly.
The planned lectures and courses for the next three years are announced online.

Workload
Total effort for 9 credits: ca. 270 hours
- Presence time: 84 hours
- Preparation/Wrap-up: 112 hours
- Examination and examination preparation: 74 hours

Recommendation
Basic knowledge as conveyed in the module Introduction to Operations Research is assumed.
Module: Optical Waveguides and Fibers [M-ETIT-100506]

**Responsible:** Prof. Dr.-Ing. Christian Koos

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** Complementary Field / Subject Electrical Engineering

<table>
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<tr>
<th>Credits</th>
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<th>Recurrence</th>
<th>Duration</th>
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<td>4</td>
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<td>Each winter term</td>
<td>1 term</td>
<td>English</td>
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</table>

**Mandatory**

| T-ETIT-101945 | Optical Waveguides and Fibers | 4 CR | Koos |

**Competence Certificate**

Type of Examination: Oral exam

Duration of Examination: approx. 20 minutes

Modality of Exam: The written exam is offered continuously upon individual appointment.

**Prerequisites**

None

**Competence Goal**

The students

- conceive the basic principles of light-matter-interaction and wave propagation in dielectric media and can explain the origin and the implications of the Lorentz model and of Kramers-Kronig relation,
- are able to quantitatively analyze the dispersive properties of optical media using Sellmeier relations and scientific databases,
- can explain and mathematically describe the working principle of an optical slab waveguide and the formation of guided modes,
- are able to program a mode solver for a slab waveguide in Matlab,
- are familiar with the basic principle of surface plasmon polariton propagation,
- know basic structures of planar integrated waveguides and are able to model special cases with semi-analytical approximations such as the Marcatili method or the effective-index method,
- are familiar with the basic concepts of numerical mode solvers and the associated limitations,
- are familiar with state-of-the-art waveguide technologies in integrated optics and the associated fabrication methods,
- know basic concepts of of step-index fibers, graded-index fibers and microstructured fibers,
- are able to derive and solve basic relations for step-index fibers from Maxwell's equations,
- are familiar with the concept of hybrid and linearly polarized fiber modes,
- can mathematically describe signal propagation in single-mode fibers design dispersion-compensated transmission links,
- conceive the physical origin of fiber attenuation effects,
- are familiar with state-of-the-art fiber technologies and the associated fabrication methods,
- can derive models for dielectric waveguide structures using the mode expansion method,
- conceive the principles of directional couplers, multi-mode interference couplers, and waveguide gratings,
- can mathematically describe active waveguides and waveguide bends.
Content

1. Introduction: Optical communications
2. Fundamentals of wave propagation in optics: Maxwell’s equations in optical media, wave equation and plane waves, material dispersion, Kramers-Kroig relation and Sellmeier equations, Lorentz and Drude model of refractive index, signal propagation in dispersive media.
3. Slab waveguides: Reflection from a plane dielectric boundary, slab waveguide eigenmodes, radiation modes, inter- and intramodal dispersion, metal-dielectric structures and surface plasmon polariton propagation.
4. Planar integrated waveguides: Basic structures of integrated optical waveguides, guided modes of rectangular waveguides (Marcatili method and effective-index method), basics of numerical methods for mode calculations (finite difference- and finite-element methods), waveguide technologies in integrated optics and associated fabrication methods
5. Optical fibers: Optical fiber basics, step-index fibers (hybrid modes and LP-modes), graded-index fibers (infinitely extended parabolic profile), microstructured fibers and photonic-crystal fibers, fiber technologies and fabrication methods, signal propagation in single-mode fibers, fiber attenuation, dispersion and dispersion compensation
6. Waveguide-based devices: Modeling of dielectric waveguide structures using mode expansion and orthogonality relations, multimode interference couplers and directional couplers, waveguide gratings, material gain and absorption in optical waveguides, bent waveguides

Module grade calculation
The module grade is the grade of the oral exam.

There is, however, a bonus system based on the problem sets that are solved during the tutorials: During the term, 3 problem sets will be collected in the tutorial and graded without prior announcement. If for each of these sets more than 70% of the problems have been solved correctly, a bonus of 0.3 grades will be granted on the final mark of the oral exam.

Workload
Total 120 h, hereof 45 h contact hours (30 h lecture, 15 h tutorial) and 75 h homework and self-studies.

Recommendation
Solid mathematical and physical background, basic knowledge of electrodynamics

Literature
B.E.A. Saleh, M.C. Teich: Fundamentals of Photonics
G.P. Agrawal: Fiber-optic communication systems
C.-L. Chen: Foundations for guided-wave optics
Katsunari Okamoto: Fundamentals of Optical Waveguides
K. Iizuka: Elements of Photonics
Module: Optimal Control and Estimation [M-ETIT-102310]

**Responsible:** Prof. Dr.-Ing. Sören Hohmann

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** Complementary Field / Subject Electrical Engineering

<table>
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</table>

**Mandatory**

| T-ETIT-104594 | Optimal Control and Estimation | 3 CR | Hohmann |

**Prerequisites**

none
Module: Optimisation and Optimal Control for Differential Equations [M-MATH-102899]

Responsible: Prof. Dr. Christian Wieners
Organisation: KIT Department of Mathematics

Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

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Mandatory

| T-MATH-105864 | Optimisation and Optimal Control for Differential Equations | 4 CR |

Prerequisites
none
3.172 Module: Optimization in Banach Spaces [M-MATH-102924]

**Responsible:** Prof. Dr. Roland Griesmaier

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Analysis
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Analysis
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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<td>Grade to a tenth</td>
<td>Irregular</td>
<td>1 term</td>
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</table>

**Competition Certificate**
The module will be completed by an oral exam (approx. 30 min).

**Prerequisites**
none

**Competence Goal**
The students can transfer properties from finite dimensional optimization problems to infinite dimensional cases. Furthermore, they can apply these results to problems from approximation theory, calculus of variation and optimal control. The students know about the main theorems and their proofs and can explain conclusions with the help of examples.

**Content**
Basics from Functional Analysis (in particular separation theorems, properties of convex functions and generalized derivatives), duality theory of convex problems, differentiable optimization problems (Lagrange multiplier), sufficient optimality conditions, existence results, applications in approximation theory, calculus of variation, and optimal control theory.

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 150 hours
Attendance: 60 hours
- lecture including course related examinations
Self-studies: 90 hours
- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research relating to the course content
- preparation for the module examination

**Recommendation**
Some basic knowledge of finite dimensional optimization theory and functional analysis is desirable.
Module: Optimization of Dynamic Systems [M-ETIT-100531]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Complementary Field / Subject Electrical Engineering

Credits 5
Grading scale Grade to a tenth
Recurrence Each winter term
Duration 1 term
Language English
Level 4
Version 1

Mandatory
T-ETIT-100685 Optimization of Dynamic Systems 5 CR Hohmann

Competence Certificate
The assessment consists of a written exam (120 min) taking place in the recess period.

Prerequisites
none

Competence Goal
- The students know as well the mathematical basics as the fundamental methods and algorithms to solve constraint and unconstraint nonlinear static optimization problems.
- They can solve constraint and unconstraint dynamic optimization by using the calculus of variations approach and the Dynamic Programming method.
- Also they are able to transfer dynamic optimization problem to static problems.
- The students know the mathematic relations, the pros and cons and the limits of the particular optimization methods.
- They can transfer problems from other fields of their studies in a convenient optimization problem formulation and they are able to select and implement suitable optimization algorithms for them by using common software tools.

Content
The module teaches the mathematical basics that are required to solve optimization problems. The first part of the lecture treats methods for solving static optimization problems. The second part of the lecture focuses on solving dynamic optimization problems by using the method of Euler-Lagrange and the Hamilton method as well as the dynamic programming approach.

Module grade calculation
The module grade is the grade of the written exam.

Workload
Each credit point stands for an amount of work of 30h of the student. The amount of work includes
1. presence in lecture/exercises/tutorial(optional) (2+1 SWS: 45h1.5 LP)
2. preparation/postprocessing of lecture/exercises (90h3 LP)
3. preparation/presence in the written exam (15h0.5 LP)
## 3.174 Module: Parallel Computing [M-MATH-101338]

**Responsible:** PD Dr. Mathias Krause  
Prof. Dr. Christian Wieners

**Organisation:** KIT Department of Mathematics

**Part of:**  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
- Additional Examinations

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<tr>
<td>T-MATH-102271</td>
<td>Parallel Computing</td>
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**Prerequisites**  
None
### 3.175 Module: Percolation [M-MATH-102905]

**Responsible:** Prof. Dr. Günter Last  
**Organisation:** KIT Department of Mathematics  
**Part of:** Mathematical Methods 1 / Field Stochastics  
**Part of:** Mathematical Methods 2 / Field Stochastics  
**Part of:** Complementary Field / Field Stochastics  
**Part of:** Mathematical Specialization  
**Additional Examinations**

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<td>Percolation</td>
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</table>

**Competence Certificate**

The module will be completed by an oral exam (ca. 30 min).

**Prerequisites**

none

**Competence Goal**

The students

- are acquainted with basic models of discrete and continuum percolation,
- acquire the skills needed to use specific probabilistic and graph-theoretical methods for the analysis of these models,
- know how to work self-organised and self-reflexive.

**Content**

- Bond and site percolation on graphs
- Infinite clusters and critical probabilities
- Asymptotics of cluster sizes
- Uniqueness of the infinite cluster
- Continuous percolation

**Module grade calculation**

The module grade is the grade of the oral exam.

**Workload**

Total workload: 150 hours  
Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 90 hours

- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research relating to the course content,  
- preparation for the module examination

**Recommendation**

The contents of the module Probability Theory are recommended.
# 3.176 Module: Photorealistic Rendering [M-INFO-100731]

**Responsible:** Prof. Dr.-Ing. Carsten Dachsbacher  
**Organisation:** KIT Department of Informatics  
**Part of:** Complementary Field / Subject Computer Science

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</table>
Module: Physiology and Anatomy for Engineers I [M-ETIT-100390]

**Responsible:** Prof. Dr. Werner Nahm

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** Complementary Field / Subject Electrical Engineering

**Credits:** 3

**Grading scale:** Grade to a tenth

**Recurrence:** Each winter term

**Duration:** 1 term

**Language:** German

**Level:** 4

**Version:** 3

**Mandatory**

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**Competence Certificate**

Success control is carried out in the form of a written test of 60 minutes.

**Prerequisites**

The module "M-ETIT-105874 – Physiologie und Anatomie für die Medizintechnik" must not been started.

**Content**

The lecture provides basic knowledge about the essential organ systems of humans and medical terminology. It is aimed at students of technical courses who are interested in physiological issues.

Thematic blocks:

- Organizational levels of the organism
- Building blocks of life
  - Proteins
  - Lipids
  - Carbohydrates
  - Lipids
  - Nucleic acids
- Cells
  - Structure
  - Membrane transport processes
  - Protein biosynthesis
  - Cell respiration
  - Nerve cells
  - Muscle cells
- Tissue
  - Tissue types
  - Cell connections
- Sensory organs
  - Eye
  - Hearing

**Module grade calculation**

The module grade is the grade of the written exam.

**Workload**

Each credit point corresponds to approximately 25-30 hours of work (of the student). This is based on the average student who achieves an average performance. The workload includes:

- Attendance time in lectures (2 h, 15 appointments each) = 30 h
- Self-study (3 h, 15 appointments each) = 45 h
- Preparation / post-processing = 15 h

**Total effort approx. 90 hours = 3 LP**
3.178 Module: Poisson Processes [M-MATH-102922]

**Responsible:** Prof. Dr. Günter Last  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
Mathematical Methods 1 / Field Stochastics  
Mathematical Methods 2 / Field Stochastics  
Complementary Field / Field Stochastics  
Mathematical Specialization  
Additional Examinations

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<td>Poisson Processes</td>
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</table>

**Competence Certificate**  
The module will be completed by an oral exam (ca. 30 min).

**Prerequisites**  
none

**Competence Goal**  
The students know about important properties of the Poisson process. The focus is on probabilistic methods and results which are independent of the specific phase space. The students understand the central role of the Poisson process as a specific point process and as a random measure.

**Content**

- The Poisson process as particular point process  
- Multivariate Mecke equation  
- Superpositions, markings and thinnings  
- Characterizations of the Poisson process  
- Stationary Poisson and point processes  
- Balanced allocations and the Gale-Shapley algorithm  
- Compound Poisson processes  
- Wiener-Ito integrals  
- Fock space representation

**Module grade calculation**  
The module grade is the grade of the oral exam.

**Workload**  
Total workload: 150 hours  
Attendance: 60 hours  
- lectures, problem classes, and examination  
Self-studies: 90 hours  
- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research relating to the course content,  
- preparation for the module examination

**Recommendation**  
The contents of the module Probability Theory are recommended.
### Module: Potential Theory [M-MATH-102879]

**Responsible:** Prof. Dr. Roland Griesmaier  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 1 / Field Applied and Numerical Mathematics  
- Mathematical Methods 2 / Field Analysis  
- Mathematical Methods 2 / Field Applied and Numerical Mathematics  
- Complementary Field / Field Analysis  
- Complementary Field / Field Applied and Numerical Mathematics  
- Mathematical Specialization  
- Additional Examinations

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**Mandatory**

| T-MATH-105850 | Potential Theory | 8 CR | Arens, Griesmaier, Hettlich, Reichel |

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**Competence Certificate**  
The module will be completed by an oral exam (30 min).

**Prerequisites**  
None

**Competence Goal**  
Students can explain basic properties of harmonic functions and prove existence and uniqueness of solutions to boundary value problems for the Laplace equation in interior and exterior domains using integral equation techniques. They master representation theorems and are able to apply single- and double layer potentials to solve boundary value problems.

**Content**

- Properties of harmonic functions
- Existence and uniqueness of boundary value problems for the Laplace equation
- Fundamental solutions and Green's functions
- Single- and double layer potentials
- Integral equations

**Module grade calculation**  
The module grade is the grade of the oral exam.

**Workload**  
Total workload: 240 hours  
- Attendance: 90 hours
  - lectures, problem classes, and examination
- Self-studies: 150 hours
  - follow-up and deepening of the course content
  - work on problem sheets
  - literature study and internet research relating to the course content
  - preparation for the module examination

**Responsible:** Prof. Dr. Daniel Hug

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

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</table>

**Mandatory**

| T-MATH-105923 | Probability Theory and Combinatorial Optimization | 8 CR | Hug, Last |

**Competence Certificate**
The module will be completed by an oral exam (ca. 30 min).

**Prerequisites**
none

**Competence Goal**
The students

- know basic problems of combinatorial optimization as discussed in the lectures and are able to explain them,
- know typical methods for the probabilistic analysis of algorithms and combinatorial optimization problems and are able to use them for the solution of specific optimization problems,
- are familiar with the essential techniques of proof and are able to explain them,
- know how to work in a self-organized and self-reflexive manner.

**Content**
This course is devoted to the analysis of algorithms and combinatorial optimization problems in a probabilistic framework. A natural setting for the investigation of such problems is often provided by a (geometric) graph. For a given system (graph), the average or most likely behavior of an objective function of the system will be studied. In addition to asymptotic results, which describe a system as its size increases, quantitative laws for systems of fixed size will be described. Among the specific problems to be explored are

- the long-common-subsequence problem,
- packing problems,
- the Euclidean traveling salesperson problem,
- minimal Euclidean matching,
- minimal Euclidean spanning tree.

For the analysis of problems of this type, several techniques and concepts have been developed and will be introduced and applied in this course. Some of these are

- concentration inequalities and concentration of measure,
- subadditivity and superadditivity,
- martingale methods,
- isoperimetry,
- entropy.

**Module grade calculation**
The module grade is the grade of the oral exam.
Workload
Total workload: 240 hours
Attendance: 90 hours
  • lectures, problem classes, and examination
Self-studies: 150 hours
  • follow-up and deepening of the course content
  • work on problem sheets
  • literature study and internet research related to the course content
  • preparation for the module exam.

Recommendation
It is recommended to have taken the module 'Probability Theory' from the Bachelor program beforehand.
3.181 Module: Random Graphs and Networks [M-MATH-106052]

Responsible: Prof. Dr. Daniel Hug
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Stochastics
           Mathematical Methods 2 / Field Stochastics
           Complementary Field / Field Stochastics
           Mathematical Specialization
           Additional Examinations

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Mandatory
T-MATH-112241 Random Graphs and Networks 8 CR Hug

Competence Certificate
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
none

Competence Goal
Students

- know the basic models of random graphs and their properties,
- are familiar with probabilistic techniques for the investigation of random graphs,
- are able to work in a self-organized and reflexive manner.

Content
In the course, models of random graphs and networks are presented and methods will be developed which allow to state and prove results about the structure of such models.

In particular, the following models are treated:

- Erdős--Renyi graphs
- Configuration models
- Preferential-Attachment graphs
- Generalized inhomogeneous random graphs
- Geometric random graphs

and the following methods are addressed:

- Branching processes
- Coupling arguments
- Probabilistic bounds
- Martingales
- Local convergence of random graphs

Module grade calculation
The grade of the module is the grade of the oral exam.

Annotation
can not be completed together with M-MATH-102951 - Random Graphs
Workload
Total workload: 240 hours
Attendance: 90 hours
  • lectures, problem classes, and examination
Self-studies: 150 hours
  • follow-up and deepening of the course content
  • work on problem sheets
  • literature study and internet research related to the course content
  • preparation for the module exam.

Recommendation
The contents of the module 'Probability Theory' are strongly recommended.
### 3.182 Module: Regularity for Elliptic Operators [M-MATH-106696]

**Responsible:** apl. Prof. Dr. Peer Kunstmann

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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#### Mandatory

| T-MATH-113472 | Regularity for Elliptic Operators | 6 CR | Kunstmann |

**Competence Certificate**
The module will be completed by an oral exam (about 30 min).

**Prerequisites**
none

**Competence Goal**
The students

- can explain methods for definition of elliptic operators,
- can name results on spectral properties in \( L^q \) and relate them,
- can explain the relevance of heat kernel estimates and sketch corresponding methods of proof,
- can sketch the construction of the \( H^\infty \) calculus and name classes of elliptic operators for which it is bounded,
- can explain the concept of \( L^p \) maximal regularity and its relation to other parts of the theory and can name examples,
- have mastered the important techniques of proofs for regularity properties of elliptic operators,
- are able to start a master thesis in the field.

**Content**

- elliptic operators in divergence and non-divergence form
- elliptic operators on domains with boundary conditions
- heat kernel estimates for elliptic operators
- spectrum of elliptic operators in Lebesgue spaces \( L^q \)
- maximal \( L^p \) regularity for the parabolic problem
- \( H^\infty \) functional calculus for elliptic operators
- \( L^q \) theory for parabolic boundary value problems

**Module grade calculation**
The grade of the module is the grade of the oral exam.

**Workload**
Total workload: 180 hours

- **Attendance:** 60 h
  - lectures, problem classes and examination

- **Self studies:** 120 h
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research on the course content,
  - preparation for the module examination
Recommendation
The modules “Functional Analysis” and “Spectral Theory” are strongly recommended.
3.183 Module: Riemann Surfaces [M-MATH-106466]

**Responsible:** Prof. Dr. Frank Herrlich  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Algebra and Geometry  
- Mathematical Methods 2 / Field Algebra and Geometry  
- Complementary Field / Field Algebra and Geometry  
- Mathematical Specialization  
- Additional Examinations

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**Mandatory**

| T-MATH-113081 | Riemann Surfaces | 8 CR | Herrlich |

**Competence Certificate**  
Oral examination of ca. 30 minutes.

**Prerequisites**  
None

**Competence Goal**  
Students know

- essential structural properties of Riemann surfaces,
- topological, analytic and algebraic methods for the investigation of Riemann surfaces, and are able to apply them.

**Content**

- Definition of Riemann surfaces  
- holomorphic and meromorphic functions on Riemann surfaces  
- Compact Riemann surfaces  
- The Riemann-Roch theorem  
- Uniformization, Fuchsian groups and hyperbolic metric  
- Classification of compact Riemann surfaces

**Module grade calculation**  
The grade of the module is the grade of the oral exam.

**Workload**  
Total workload: 240 hours  
Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,  
- work on problem sheets,  
- literature study and internet research on the course content,  
- preparation for the module examination

**Recommendation**  
Some knowledge of complex analysis (e.g. "Analysis 4") is strongly recommended as well as the modules "Elementary Geometry" and "Introduction to Algebra and Number Theory".
Module: Robotics I - Introduction to Robotics [M-INFO-100893]

**Responsible:** Prof. Dr.-Ing. Tamim Asfour

**Organisation:** KIT Department of Informatics

**Part of:** Complementary Field / Subject Computer Science

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<td>Robotics I - Introduction to Robotics</td>
<td>6 CR</td>
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</table>

**Competence Certificate**

See partial achievements (Teilleistung)

**Prerequisites**

See partial achievements (Teilleistung)

**Competence Goal**

The students are able to apply the presented concepts to simple and realistic tasks from robotics. This includes mastering and deriving the mathematical concepts relevant for robot modeling. Furthermore, the students master the kinematic and dynamic modeling of robot systems, as well as the modeling and design of simple controllers. The students know the algorithmic basics of motion and grasp planning and can apply these algorithms to problems in robotics. They know algorithms from the field of image processing and are able to apply them to problems in robotics. They are able to model and solve tasks as a symbolic planning problem. The students have knowledge about intuitive programming procedures for robots and know procedures for programming and learning by demonstration.

**Content**

The lecture provides an overview of the fundamentals of robotics using the examples of industrial robots, service robots and autonomous humanoid robots. An insight into all relevant topics is given. This includes methods and algorithms for robot modeling, control and motion planning, image processing and robot programming. First, mathematical basics and methods for kinematic and dynamic robot modeling, trajectory planning and control as well as algorithms for collision-free motion planning and grasp planning are covered. Subsequently, basics of image processing, intuitive robot programming especially by human demonstration and symbolic planning are presented.

In the exercise, the theoretical contents of the lecture are further illustrated with examples. Students deepen their knowledge of the methods and algorithms by independently working on problems and discussing them in the exercise. In particular, students can gain practical programming experience with tools and software libraries commonly used in robotics.

**Workload**

Lecture with 3 SWS + 1 SWS Tutorial, 6 LP

6 LP corresponds to 180 hours, including

15 * 3 = 45 hours attendance time (lecture)
15 * 1 = 15 hours attendance time (tutorial)
15 * 6 = 90 hours self-study and exercise sheets
30 hours preparation for the exam
3.185 Module: Ruin Theory [M-MATH-104055]

Responsible: Prof. Dr. Vicky Fasen-Hartmann
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Stochastics
         Mathematical Methods 2 / Field Stochastics
         Complementary Field / Field Stochastics
         Mathematical Specialization
         Additional Examinations

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Competence Certificate

The module will be completed by an oral exam (approx. 20 min).

Prerequisites

None

Competence Goal

Students are able to

- name and discuss key concepts and results of ruin theory with applications in actuarial mathematics and can apply them to examples,
- apply specific probabilistic methods to analyse risk processes,
- master proof techniques,
- work in a self-orientated and reflective manner.

Content

- renewal theory
- classical risk process of Cramér and Lundberg
- asymptotic behaviour of the probability of ruin probability if the Lundberg constant exists (losses with light tailed distributions)
- subexponential distributions
- asymptotic behaviour of the probability of ruin if the losses are subexponentially distributed (losses with heavy tailed distributions)
- approximation of the ruin probability
- integrated risk processes
- portfolio of risk processes

Module grade calculation

The grade of the module is the grade of the oral exam.

Workload

Total workload: 120 hours

Attendance: 45 hours

- lectures and problem classes including the examination

Self studies: 75 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature and internet research on the course content
- preparation for the module examination
Recommendation
The content of the module "Probability Theory" is recommended.
Module: Scattering Theory [M-MATH-102884]

Responsible: PD Dr. Frank Hettlich
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Analysis
Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Analysis
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Analysis
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

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Competence Certificate
The module will be completed by an oral exam (~30min.)

Prerequisites
none

Competence Goal
The students can prove and apply basic properties of solutions of the Helmholtz equation in the interior and in the exterior of a domain. They know about the representation theorems for such solutions. Students can explain the existence theory of corresponding boundary value problems by integral equations and/or variational formulations including appropriate proofs. Furthermore, the students can show and apply the dependence of a scattered field on the scattering object and the wave number as well as the relationship with its far field pattern.

Content
- Helmholtz equation and elementary solutions
- Greens representation theorems
- Existence and uniqueness of scattering problems
- Radiation condition and far field pattern

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240h
Attendance: 90h
- lecture, problem class, examination
Self-studies: 150h
- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research related to the course content
- preparation for the module exam

Recommendation
One of the following modules should already be covered: functional analysis or integral equations
3.187 Module: Scattering Theory for Time-dependent Waves [M-MATH-106664]

**Responsible:** Prof. Dr. Roland Griesmaier

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Analysis
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Analysis
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

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<tr>
<td>T-MATH-113416</td>
<td>Scattering Theory for Time-dependent Waves</td>
<td>6 CR</td>
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</table>

**Competence Certificate**
The module will be completed with an oral exam of about 30 minutes.

**Prerequisites**
None

**Competence Goal**
The students can prove and apply basic properties of solutions of the wave equation in interior or exterior domains. They know about representation theorems for such solutions and can apply the Fourier-Laplace-transform to analyze causal solutions. Students master the existence and uniqueness theory of associated boundary value problems using integral equations and retarded single and double layer potentials including proofs. Furthermore, the students can apply these results to scattering problems and explain the dependence of scattered waves on the scattering object as well as the relationship with its far field pattern.

**Content**
- Wave equations and elementary solutions
- Representation theorems
- Fourier-Laplace-transform
- Boundary element formulations of boundary value problems for the wave equation
- Existence and uniqueness of solutions to interior and exterior boundary value problems
- Scattering problems and far field patterns

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 180 hours
- Attendance: 60 h
- Self studies: 120 h

**Recommendation**
The modules Functional Analysis and/or Integral Equations are recommended.
**Module: Selected Methods in Fluids and Kinetic Equations [M-MATH-105897]**

**Responsible:** Prof. Dr. Wolfgang Reichel

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

| T-MATH-111853 | Selected Methods in Fluids and Kinetic Equations | 3 CR |

**Competence Certificate**
The module will be completed with an oral exam (approx. 30 min).

**Prerequisites**
none

**Competence Goal**
The main aim of this lecture is to introduce students to tools and techniques developed in recent years to analyze the evolution of fluids and kinetic equations. The students will learn how to use these techniques and how to apply them to families of equations.

**Content**
In this lecture we discuss selected techniques and tools that have lead to significant progress in the analysis of fluids and kinetic equations. These, for instance, include:
- energy methods and local well-posedness results (e.g. fixed point results, Osgood lemma)
- Newton iteration
- Cauchy-Kowalewskaya and ghost energy approaches

No prior knowledge of fluids or kinetic equations is required.

**Module grade calculation**
The grade of the module is the grade of the oral exam.

**Workload**
The grade of the module is the grade of the oral exam.

<table>
<thead>
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<th>Total workload: 90 hours</th>
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**Attendance:** 30 h
- lectures and examination

**Self studies:** 60 h
- follow-up and deepening of the course content,
- literature study and internet research on the course content,
- preparation for the module examination

**Recommendation**
The modules "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.
### 3.189 Module: Selected Topics in Cryptography [M-INFO-100836]

<table>
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<tr>
<th>Responsible</th>
<th>Prof. Dr. Jörn Müller-Quade</th>
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<tr>
<td>T-INFO-101373</td>
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3.190 Module: Selected Topics in Harmonic Analysis [M-MATH-104435]

Responsible: Prof. Dr. Dirk Hundertmark
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Analysis
Mathematical Methods 2 / Field Analysis
Complementary Field / Field Analysis
Mathematical Specialization
Additional Examinations

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| T-MATH-109065 | Selected Topics in Harmonic Analysis | 3 CR | Hundertmark |

Prerequisites
None

Competence Goal
The students are familiar with the concepts of singular integral operators and weighted estimates in Harmonic Analysis. They know the relations between the BMO space and the Muckenhoupt weights and also how to use dyadic analysis operators to obtain estimates for Calderon-Zygmund operators.

Content
- Calderon-Zygmund and Singular Integral operators
- BMO space and Muckenhoupt weights
- Reverse Holder Inequality and Factorisation of Ap weights
- Extrapolation Theory and weighted norm inequalities for singular integral operators
3.191 Module: Semigroup Theory for the Navier-Stokes Equations [M-MATH-106663]

Responsibility: Dr. rer. nat. Patrick Tolksdorf

Organisation: KIT Department of Mathematics

Part of:
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

Credits: 6

Grading scale: Grade to a tenth

Recurrence: Irregular

Duration: 1 term

Language: English

Level: 4

Version: 1

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<td>Semigroup Theory for the Navier-Stokes Equations</td>
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Competence Certificate
The module will be completed with an oral exam of about 30 minutes.

Prerequisites
None

Competence Goal
After a successful participation of the course, students are familiar with essential concepts of semigroup theory, such as analytic semigroups and fractional powers of sectorial operators. They are able to apply these concepts to the Stokes operator and derive basic regularity properties of solutions to the Stokes equations. Furthermore, they can use these concepts to construct solutions to the Navier-Stokes equations in critical spaces through an iteration scheme.

Content
Content from abstract semigroup theory:
- Sectorial operators
- Analytic semigroups
- Fractional powers

Content from fluid mechanics:
- Helmholtz decomposition
- Bogovskii operator
- Stokes operator
- Mapping properties of the Stokes semigroup
- Solvability of the Navier-Stokes equations in critical spaces

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 h
- lectures, problem classes and examination

Self studies: 120 h
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination
**Recommendation**

The following modules are strongly recommended: *Functional Analysis* and *Classical Methods for Partial Differential Equations.*
3.192 Module: Seminar [M-MATH-102730]

**Responsible:** PD Dr. Stefan Kühnlein

**Organisation:** KIT Department of Mathematics

**Part of:** Mathematical Seminar

<table>
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**Elective Seminar (Election: 1 item)**

| T-MATH-105686 | Seminar Mathematics | 3 CR | Kühnlein |

**Competence Certificate**
The control of success (pass/fail) is based on a seminar talk lasting at least 45 minutes.

**Prerequisites**
None

**Competence Goal**
At the end of the module, participants should

- have analyzed a specific problem in a mathematical area
- be able to discuss subject-specific problems in the given context and present as well as defend them, using suitable media
- have summarized the most relevant results of their topic
- have communicative, organizational and didactic skills in complex problem analyses at their disposal. They can use techniques of scientific work.

**Content**
The specific content is based on the seminar topics being offered.

**Module grade calculation**
Omitted, as ungraded (pass/fail)

**Workload**
Total work load: 90 hours

- Attendance: 30 hours
- Self studies: 60 hours
  - Preparation of the scientific content of the talk
  - Preparation of a didactical concept for the talk
  - Preparation of the presentation (blackboard, beamer, etc.)
  - getting practice for the talk, creating a hand-out
3.193 Module: Seminar [M-MATH-103276]

Responsible: PD Dr. Stefan Kühnlein

Organisation: KIT Department of Mathematics

Part of: Mathematical Specialization

<table>
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| T-MATH-106541 | Seminar Mathematics | 3 CR |

Competence Certificate
The control of success (pass/fail) is based on a seminar talk lasting at least 45 minutes.

Prerequisites
none

Competence Goal
At the end of the module the participants should

- have analyzed a specific problem in a mathematical area
- be able to discuss subject-specific problems in the given context and present as well as defend them, using suitable media
- have summarized the most relevant results of their topic
- have communicative, organizational and didactic skills in complex problem analyses at their disposal. They can use techniques of scientific work.

Content
The specific content is based on the seminar topics being offered.

Module grade calculation
omitted as ungraded (pass/fail)

Workload
Total work load: 90 hours

Attendance: 30 hours
Self studies: 60 hours

- Preparation of the scientific content of the talk
- Preparation of a didactical concept for the talk
- Preparation of the presentation (blackboard, beamer, etc.)
- getting practice for the talk, creating a hand-out
**Module: Seminar 2 [M-MATH-103925]**

**Responsible:** PD Dr. Stefan Kühnlein  
**Organisation:** KIT Department of Mathematics  
**Part of:** Mathematical Seminar

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**Mandatory**

| T-MATH-108020 | Seminar Mathematics 2 | 3 CR |

**Competence Certificate**  
The control of success (pass/fail) is based on a seminar talk lasting at least 45 minutes.

**Prerequisites**  
None

**Competence Goal**  
At the end of the module, the participants should

- have analyzed a specific problem in a mathematical area
- be able to discuss subject-specific problems in the given context and present as well as defend them, using suitable media.
- have summarized the most relevant results of their topic
- have communicative, organizational and didactic skills in complex problem analyses at their disposal. They can use techniques of scientific work.

**Content**  
The specific content is based in the seminar topics being offered.

**Module grade calculation**  
Omitted, as ungraded (pass/fail)

**Workload**  
Total work load: 90 hours  
Attendance: 30 hours  
Self studies: 60 hours

- Preparation of the scientific content of the talk
- Preparation of a didactical concept for the talk
- Preparation of the presentation (blackboard, beamer, etc.)
- Getting practice for the talk, creating a hand-out
### 3.195 Module: Seminar Advanced Topics in Parallel Programming [M-INFO-101887]

**Responsible:** Prof. Dr. Achim Streit  
**Organisation:** KIT Department of Informatics  
**Part of:** Complementary Field / Subject Computer Science  

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Streit
### 3.196 Module: Signal Processing with Nonlinear Fourier Transforms and Koopman Operators [M-ETIT-106675]

**Responsible:** Prof. Dr.-Ing. Sander Wahls  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Complementary Field / Subject Electrical Engineering

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<td>Signal Processing with Nonlinear Fourier Transforms and Koopman Operators</td>
<td>6 CR</td>
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**Competence Certificate**

The examination in this module consists of programming assessments and a graded written examination of 120 minutes. The programming assignments are either pass or fail. They must be passed during the lecture period for admission to the written examination.

**Prerequisites**

none

**Competence Goal**

Students

- understand the basic theory of linear operator on Hilbert spaces and can analyze simple operators analytically
- know the use cases for selected integrable partial differential equations (PDEs) and can apply them under non-ideal circumstances (small non-integrable terms)
- can determine the PDE corresponding to a given Lax-pair and check if the PDE is actually integrable (i.e. check if the Lax pair is "fake")
- understand the theory of nonlinear Fourier analysis for selected PDEs and can compute nonlinear (inverse) Fourier transforms numerically and, in simple cases, analytically
- know and implement practical engineering applications of nonlinear Fourier transforms
- understand the theory of the Koopman operator including selected engineering applications
- compute Koopman spectra numerically using data-driven methods and use them in practical engineering applications
Content
This module introduces students to signal processing methods that rely on nonlinear Fourier transforms and Koopman operators. These methods allow us to transform large classes of nonlinear systems such that they essentially behave like linear systems. They can also be used to decompose signals driven by such systems into physically meaningful nonlinear wave components (for example, solitons).

While these methods originated in mathematical physics, there has been a growing interest in exploiting their unique capabilities in engineering contexts. The goal of this module is to give engineering students a practical introduction to this area. It provides the necessary theoretical background, enables students to apply the methods in practice via computer assignments, and discusses recent research from the engineering literature.

The following topics will be discussed:

- Introduction to linear operators on Hilbert spaces
- Integrable model systems (Korteweg-de Vries equation, Nonlinear Schrödinger equation)
- Lax-integrable systems (representations of Lax pairs, fake Lax pairs, conserved quantities)
- Solution of integrable model systems using nonlinear Fourier transforms (inverse scattering method) and the unified transform method
- Physical interpretation of nonlinear Fourier spectra (in particular, solitons)
- Practical applications of nonlinear Fourier transforms
- Theoretical properties of Koopman operators
- Data-driven computation of Koopman operators (residual dynamic mode decomposition)
- Practical applications of Koopman operators

Module grade calculation
The module grade is the grade of the written exam.

Annotation
Some tutorial sessions will be classically devoted to solving pen and paper problems, but in others students will be working on their practical computer assignments. For the latter, students have to bring their own laptops with Matlab installed. The solutions of the computer assignments must be submitted by the provided deadlines, which are typically one week after the corresponding tutorial has taken place.

Workload
The workload includes:

1. attendance in lectures and tutorials: 15*4 h = 60 h
2. preparation / follow-up: 30*3 h = 60 h
3. finishing programming assignments: 30 h
4. preparation of and attendance in examination: 30 h

A total of 180 h = 6 CR

Recommendation
Familiarity with signals and systems at the Bachelor level (Fourier and Laplace transforms, linear systems, etc.) is assumed.
3.197 Module: Sobolev Spaces [M-MATH-102926]

**Responsible:** Prof. Dr. Roland Schnaubelt

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Analysis
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Analysis
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

| T-MATH-105896 | Sobolev Spaces | 8 CR | Schnaubelt |

**Competence Certificate**
The module will be completed by an oral exam (ca. 30 min).

**Prerequisites**
None

**Competence Goal**
Students can explain the significance of Sobolev spaces in the theory of partial differential equations. They are able to reproduce and prove the most important properties.

**Content**
Definition of Sobolev spaces for functions on Lipschitz domains, density, continuation and trace theorems, compact embeddings, Helmholtz decomposition, simple applications to partial differential equations.

**Module grade calculation**
The grade of the module is the grade of the oral exam.

**Workload**
Total workload: 240 hours

- Attendance: 90 h
  - lectures, problem classes and examination
- Self studies: 150 h
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research on the course content,
  - preparation for the module examination

**Recommendation**
The contents of the module "Functional Analysis" are strongly recommended.
3.198 Module: Space and Time Discretization of Nonlinear Wave Equations
[M-MATH-105966]

**Responsible:** Dr. rer. nat. Benjamin Dörich
Prof. Dr. Marlis Hochbruck

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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<tr>
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<td>Space and Time Discretization of Nonlinear Wave Equations</td>
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</table>

**Competence Certificate**

Oral exam of approximately 20 minutes.

**Prerequisites**

None.

**Competence Goal**

Graduates

- can name and discuss essential concepts of error analysis of space and time discretizations for nonlinear wave equations,
- are prepared to write a thesis in the field of numerics of partial differential equations.

**Content**

The topic of the lecture is a unified error analysis of the space and time discretization of nonlinear wave-like equations. For this purpose, evolution equations with monotone operators on Hilbert spaces and different types of space discretization are considered, e.g. finite elements, discontinuous Galerkin methods or spectral methods, and, in particular, non-conformal discretizations.

After the analysis of the space discretization errors, this is combined with time integration methods such as the Crank-Nicolson and an implicit-explicit method.

The abstract analysis is illustrated with concrete examples.

**Module grade calculation**

The grade of the module is the grade of the oral exam.

**Workload**

Total workload: 180 h

Attendance: 60 h

- lectures, problem classes, and examination

Self-studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination.

**Recommendation**

Basic knowledge of partial differential equations and the contents of the modules M-MATH-102888 - Numerische Methoden für Differentialgleichungen and M-MATH-102891 - Finite Elemente Methoden are strongly recommended. Knowledge of functional analysis is also recommended.
3.199 Module: Spatial Stochastics [M-MATH-102903]

**Responsible:** Prof. Dr. Günter Last

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

**Mandatory**

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| T-MATH-105867 | Spatial Stochastics | 8 CR      | Hug. Last, Winter |

**Competence Certificate**
The module will be completed by an oral exam (ca. 30 min).

**Prerequisites**
none

**Competence Goal**
The students are familiar with some basic spatial stochastic processes. They do not only understand how to deal with general properties of distributions, but also know how to describe and apply specific models (Poisson process, Gaussian random fields). They know how to work self-organised and self-reflexive.

**Content**
- Random sets
- Point processes
- Random measures
- Palm distributions
- Random fields
- Gaussian fields
- Spectral theory of random fields
- Spatial ergodic theorem

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 240 hours

- Attendance: 90 hours
  - lectures, problem classes, and examination
- Self-studies: 150 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

**Recommendation**
The contents of the module *Probability Theory* are recommended.
Module: Special Topics of Numerical Linear Algebra [M-MATH-102920]

**Responsible:** Prof. Dr. Marlis Hochbruck

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

**Credits:** 8

**Grading scale:** Grade to a tenth

**Recurrence:** see Annotations

**Duration:** 1 term

**Language:** English

**Level:** 4

**Version:** 1

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**Mandatory**

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<tr>
<td>T-MATH-105891</td>
<td>Special Topics of Numerical Linear Algebra</td>
<td>8 CR</td>
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</table>

**Competence Certificate**

Oral exam of approximately 30 minutes.

**Prerequisites**

None.

**Competence Goal**

At the end of the course, students possess informed knowledge of methods and concepts of numerical linear algebra for large matrices. For various applications, they choose and implement the right numerical methods and they are able to assess and establish convergence properties of these methods. Students are able to solve problems in a self-organized and reflective manner, and to present and discuss solutions.

**Content**

- Direct methods for sparse linear systems
- Krylov subspace methods for large linear systems and eigenvalue problems
- Matrix functions

**Module grade calculation**

The module grade is the grade of the oral exam.

**Annotation**

Bi-yearly course.

**Workload**

Total workload: 240 h

- Attendance: 90 h
  - lectures, problem classes, and examination

Self-studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination.

**Recommendation**

Numerical analysis 1 and 2.
Module: Spectral Theory [M-MATH-101768]

**Responsible:** Prof. Dr. Dorothee Frey

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

| T-MATH-103414 Spectral Theory - Exam | 8 CR Frey, Herzog, Kunstmann, Schnaubelt, Tolksdorf |

**Competence Certificate**

Oral examination of approx. 30 minutes.

**Prerequisites**

none

**Competence Goal**

After participation, students

- understand the concepts of spectrum and resolvent of closed operators on Banach spaces.
- know their basic properties and are able to explain them in simple examples.
- can explain and justify the special features of compact operators and the Fredholm Alternative.
- can deduce algebraic identities and norm bounds for operators by means of the Dunford functional calculus and the spectral calculus for self-adjoint operators. This in particular includes spectral projections and spectral mapping theorems.
- are able to apply this general theory to integral and differential equations, and recognize the importance of spectral theoretic methods in Analysis.

**Content**

- Closed operators on Banach spaces,
- Spectrum and resolvent,
- Compact operators and Fredholm alternative,
- Dunford functional calculus, spectral projections,
- Fourier transform,
- Unbounded self-adjoint operators on Hilbert spaces,
- Spectral theorem,
- Sesquilinear forms and sectorial operators,
- Applications to partial differential equations.

**Module grade calculation**

The grade of the module is the grade of the oral exam.
**Workload**
Total workload: 240 hours

Attendance: 90 h
- lectures, problem classes and examination

Self studies: 150 h
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

**Recommendation**
The module „Functional Analysis“ is strongly recommended.

**Responsible:** Prof. Dr. Michael Plum  
**Organisation:** KIT Department of Mathematics  
**Part of:**  
- Mathematical Methods 1 / Field Analysis  
- Mathematical Methods 2 / Field Analysis  
- Complementary Field / Field Analysis  
- Mathematical Specialization  
- Additional Examinations

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<td>Spectral Theory of Differential Operators</td>
<td>8</td>
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**Responsible:** Prof. Dr. Tobias Jahnke

**Organisation:** KIT Department of Mathematics

**Part of:** Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

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<th>Course Title</th>
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<tr>
<td>T-MATH-110805</td>
<td>Splitting Methods for Evolution Equations</td>
<td>6 CR</td>
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</table>

**Competence Certificate**
The module will be completed by an oral exam (about 30 min).

**Prerequisites**
None

**Competence Goal**
After attending the course, students can explain the concept and the advantages of splitting methods. They know important examples of such methods and typical problem classes to which these methods can be applied. They can explain the relation between classical order and accuracy, and they know the (classical) order conditions of such methods. Students can reproduce and explain error estimates for splitting methods for linear and nonlinear evolution equations, and to explain the essential steps of the proof as well as the relevance of the made assumptions.

**Content**
- Concept and advantages of splitting methods
- Splitting methods for ordinary differential equations
- Baker-Campbell-Hausdorff formula and order conditions
- Tools from operator theory
- Splitting methods for linear evolution equations (Schrödinger equation, parabolic problems)
- Splitting methods for nonlinear evolution equations (nonlinear Schrödinger equation, Gross-Pitaevskii equation, Korteweg-de Vries equation)

**Module grade calculation**
The module grade is the grade of the oral exam.

**Annotation**
The module will be offered about every second summer semester.

**Workload**
Total workload: 180 hours

- Attendance: 60 hours
  - lectures, problem classes, and examination

- Self-studies: 120 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

**Recommendation**
Familiarity with ordinary differential equations, Runge-Kutta methods (construction, order, stability) and Sobolev spaces (definition, basic properties, Sobolev embeddings) is strongly recommended.
3.204 Module: Statistical Learning [M-MATH-105840]

**Responsible:** Prof. Dr. Mathias Trabs

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

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<tr>
<td>T-MATH-111726</td>
<td>Statistical Learning</td>
<td>8 CR</td>
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</table>

**Competence Certificate**
The module will be completed with an oral exam (approx. 30 min).

**Prerequisites**
none

**Competence Goal**
At the end of the course, students
- know the fundamental principles and problems of machine learning and can relate learning methods to these,
- are able to explain how selected machine learning methods work and can apply these,
- are able to derive and to discuss a statistical analysis of selected learning methods,
- are able to independently develop and apply new learning methods.

**Content**
The course aims for a rigorous and mathematical analysis of some popular machine learning methods with a focus is on statistical aspects. Topics are:

- **Regression**
  - Empirical risk minimization
  - Lasso
  - Regression trees and Random forests
- **Classification**
  - Bayes classifier
  - model based classifiers (e.g. logistic regression, discriminant analysis)
  - model-free classifiers (e.g. k nearest neighbors, support vector machines)
- **Neural networks**
  - training
  - approximation properties
  - statistical analysis
- **Unsupervised learning**
  - principle component analysis
  - clustering
  - generative models

**Module grade calculation**
The grade of the module is the grade of the oral exam.
**Workload**

Total workload: 240 hours

Attendance: 90 hours
- lectures, problem classes, and examination

Self-studies: 150 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

**Recommendation**

The modules "Probability Theory" and "Statistics" (M-MATH-103220) are recommended.
3.205 Module: Steins Method with Applications in Statistics [M-MATH-105579]

**Responsible:** Dr. rer. nat. Bruno Ebner

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

| T-MATH-111187 | Steins Method with Applications in Statistics | 4 CR | Ebner, Hug |

**Prerequisites**

None
Module: Stochastic Control [M-MATH-102908]

**Responsible:** Prof. Dr. Nicole Bäuerle

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

### Credits

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<td>T-MATH-105871</td>
<td>Stochastic Control</td>
<td>4 CR</td>
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</table>

**Competence Certificate**
The module will be completed by an oral exam (about 20 min).

**Prerequisites**
none

**Competence Goal**
At the end of the course, students

- can name the mathematical foundations of stochastic control and and are able to apply solution techniques,
- can formulate continuous-time dynamic stochastic optimization problems as stochastic control problems,
- are able to work in a self-organized and reflective manner,

**Content**

- Verification techniques, Hamilton-Jacobi-Bellman equation
- Viscosity solution
- Singular control
- Feynman-Kac representations
- Applications from finance and insurance

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 120 hours

- Attendance: 45 hours
  - lectures, problem classes, and examination

- Self-studies: 75 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

**Recommendation**
The course 'Probably Theory' is strongly recommended. The courses 'Brownian motion' and 'Continuous time finance' are recommended.
3.207 Module: Stochastic Differential Equations [M-MATH-102881]

**Responsible:** Prof. Dr. Dorothee Frey

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Analysis
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Analysis
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

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</table>

**Content**

- Brownian motion
- Martingales and Martingal inequalities
- Stochastic integrals and Ito's formula
- Existence and uniqueness of solutions for systems of stochastic differential equations
- Perturbation and stability results
- Application to equations in financial mathematics, physics and engineering
- Connection with diffusion equations and potential theory
3.208 Module: Stochastic Geometry [M-MATH-102865]

**Responsible:** Prof. Dr. Daniel Hug  
**Organisation:** KIT Department of Mathematics  
**Part of:** Mathematical Methods 1 / Field Algebra and Geometry  
Mathematical Methods 1 / Field Stochastics  
Mathematical Methods 2 / Field Algebra and Geometry  
Mathematical Methods 2 / Field Stochastics  
Complementary Field / Field Algebra and Geometry  
Complementary Field / Field Stochastics  
Mathematical Specialization  
**Additional Examinations**

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**Mandatory**

| T-MATH-105840 | Stochastic Geometry | 8 CR | Hug, Last, Winter |

**Competence Certificate**

The module will be completed by an oral exam (ca. 30 min).

**Prerequisites**

None

**Competence Goal**

The students

- know the fundamental geometric models and characteristics in stochastic geometry,
- are familiar with properties of Poisson processes of geometric objects,
- know examples of applications of models of stochastic geometry,
- know how to work self-organised and self-reflexive.

**Content**

- Random Sets
- Geometric Point Processes
- Stationarity and Isotropy
- Germ Grain Models
- Boolean Models
- Foundations of Integral Geometry
- Geometric densities and characteristics
- Random Tessellations

**Module grade calculation**

The module grade is the grade of the oral exam.

**Workload**

Total workload: 240 hours  
Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research related to the course content
- preparation for the module exam.
**Recommendation**
It is recommended to have taken the module 'Spatial Stochastics' beforehand.
### Module: Stochastic Information Processing [M-INFO-100829]

**Responsible:** Prof. Dr.-Ing. Uwe Hanebeck  
**Organisation:** KIT Department of Informatics  
**Part of:** Complementary Field / Subject Computer Science

<table>
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<td>6 CR</td>
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3.210 Module: Stochastic Simulation [M-MATH-106053]

**Responsible:** TT-Prof. Dr. Sebastian Krumscheid

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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<td>Stochastic Simulation</td>
<td>5 CR</td>
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**Competence Certificate**
oral exam of ca. 30 min

**Prerequisites**
None

**Competence Goal**
After successfully taking part in the module's classes and the exam, students will be acquainted with sampling-based computational tools used to analyze systems with uncertainty arising in engineering, physics, chemistry, and economics. Specifically, by the end of this course, students will be able to analyze the convergence of sampling algorithms and implement the discussed sampling methods for different stochastic processes as computer codes. Understanding the advantages and disadvantages of different sampling-based methods, the students can, in particular, choose appropriate stochastic simulation techniques and propose efficient sampling methods for a specific stochastic problem. In particular, they can name and discuss essential theoretical concepts, and understand the structure of the sampling-based computational methods. Finally, the course prepares students to write a thesis in the field of Uncertainty Quantification.

**Content**
The course covers mathematical concepts and computational tools used to analyze systems with uncertainty arising across various application domains. First, we will address stochastic modelling strategies to represent uncertainty in such systems. Then we will discuss sampling-based methods to assess uncertain system outputs via stochastic simulation techniques. The focus of this course will be on the theoretical foundations of the discussed techniques, as well as their methodological realization as efficient computational tools. Topics covered include:

- Random variable generation
- Simulation of random processes
- Simulation of Gaussian random fields
- Monte Carlo method; output analysis
- Variance reduction techniques
- Rare event simulations
- Quasi Monte Carlo methods
- Markov Chain Monte Carlo methods (Metropolis-Hasting, Gibbs sampler)

**Module grade calculation**
The grade of the module is the grade of the oral exam.

**Workload**
total workload: 150 hours

**Recommendation**
The contents of the modules 'M-MATH-101321 - Introduction to Stochastics' and 'M-MATH-103214 – Numerical Mathematics 1+2' are recommended.
Module: Structural Graph Theory [M-MATH-105463]

**Responsible:** Prof. Dr. Maria Aksenovich

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Algebra and Geometry
- Complementary Field / Field Algebra and Geometry
- Mathematical Specialization
- Additional Examinations

**Credits:** 4

**Grading scale:** Grade to a tenth

**Recurrence:** Irregular

**Duration:** 1 term

**Language:** English

**Level:** 4

**Version:** 1

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**Prerequisites**
None

**Competence Goal**
After successful completion of the course, the participants should be able to present and analyse main results in Structural Graph Theory. They should be able to establish connections between graph minors and other graph parameters, give examples, and apply fundamental results to related problems.

**Content**
The purpose of this course is to provide an introduction to some of the central results and methods of structural graph theory. Our main point of emphasis will be on graph minor theory and the concepts devised in Robertson and Seymour's intricate proof of the Graph Minor Theorem: in every infinite set of graphs there are two graphs such that one is a minor of the other.

Our second point of emphasis (time permitting) will be on Hadwiger's conjecture: that every graph with chromatic number at least r has a K_r minor. We shall survey what is known about this conjecture, including some very recent progress.

**Recommendation**
A solid background in the fundamentals of graph theory.
### Module: Supplementary Studies on Culture and Society [M-ZAK-106235]

**Responsible:** Dr. Christine Mielke
Christine Myglas

**Organisation:**

**Part of:** Additional Examinations

<table>
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<th>Grading scale Grade to a tenth</th>
<th>Recurrence Each term</th>
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**Election notes**

With the exception of the final oral exam and the practice module, students have to self-record the achievements obtained in the Supplementary Studies on Culture and Society in their study plan. ZAK records the achievements as "non-assigned" under "ÜQ/SQ-Leistungen". Further instructions on self-recording of achievements can be found in the FAQ at [https://campus.studium.kit.edu/](https://campus.studium.kit.edu/) and on the ZAK homepage at [https://www.zak.kit.edu/begleitstudium-bak.php](https://www.zak.kit.edu/begleitstudium-bak.php). The title of the examination and the amount of credits override the modules placeholders.

If you want to use ZAK achievements **both for your interdisciplinary qualifications and for the supplementary studies**, please record them in the interdisciplinary qualifications first. You can then get in contact with the ZAK study services (stg@zak.kit.edu) to also record them in your supplementary studies.

In the in-depth module, achievements have to be obtained in three different areas. The areas are as follows:

- Technology & Responsibility
- Doing Culture
- Media & Aesthetics
- Spheres of Life
- Global Cultures

You have to obtain two achievements with 3 credits each and one achievement with 5 credits. To self-record achievements in the in-depth module, you first have to elect the matching partial achievement.

**Note:** If you registered for the Supplementary Studies on Sustainable Development before April 1st, 2023, self-recording an achievement in this module counts as a request in the sense of §20 (2) of the regulations for the Supplementary Studies on Culture and Society. Your overall grade for the supplementary studies will thus be calculated as the average of the examination grades, not as the average of the module grades.

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<tr>
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<td>T-ZAK-112653</td>
<td>Basics Module - Self Assignment BAK</td>
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<tr>
<td>T-ZAK-112654</td>
<td>In-depth Module - Technology &amp; Responsibility - Self Assignment BAK</td>
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<td>T-ZAK-112655</td>
<td>In-depth Module - Doing Culture - Self Assignment BAK</td>
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<td>T-ZAK-112657</td>
<td>In-depth Module - Spheres of Life - Self Assignment BAK</td>
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<tr>
<td>T-ZAK-112658</td>
<td>In-depth Module - Global Cultures - Self Assignment BAK</td>
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<table>
<thead>
<tr>
<th>Competence Certificate</th>
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</thead>
<tbody>
<tr>
<td>The monitoring is explained in the respective partial achievement.</td>
</tr>
<tr>
<td>They are composed of:</td>
</tr>
<tr>
<td>• minutes</td>
</tr>
<tr>
<td>• presentations</td>
</tr>
<tr>
<td>• a seminar paper</td>
</tr>
<tr>
<td>• an internship report</td>
</tr>
<tr>
<td>• an oral examination</td>
</tr>
</tbody>
</table>

After successful completion of the supplementary studies, the graduates receive a graded certificate and a KIT certificate.
Prerequisites
The offer is study-accompanying and does not have to be completed within a defined period of time. Enrolment or acceptance for graduation must be present when registering for the final examination.

KIT students register for the supplementary studies by selecting this module in the student portal and self-checking a performance. In addition, registration for the individual courses is necessary, which is possible shortly before the beginning of each semester.

The course catalogue, statutes (study regulations), registration form for the oral exam, and guides for preparing the various written performance requirements can be found as downloads on the ZAK homepage at www.zak.kit.edu/begleitstudium-bak.

Competence Goal
Graduates of the Supplementary Studies on Culture and Society demonstrate a sound basic knowledge of conditions, procedures and concepts for analysing and shaping fundamental social development tasks in connection with cultural topics. They have gained a well-founded theoretical and practical insight into various cultural studies and interdisciplinary topics in the field of tension between culture, technology and society in the sense of an expanded concept of culture.

They are able to place the contents selected from the specialization module in the basic context as well as to analyse and evaluate the contents of the selected courses independently and exemplarily and to communicate about them scientifically in written and oral form. Graduates are able to analyse social topics and problem areas and critically reflect on them in a socially responsible and sustainable perspective.

Content
The Supplementary Studies on Culture and Society can be started from the 1st semester and is not limited in time. It comprises at least 3 semesters. The supplementary studies are divided into 3 modules (basics, in-depth studies, practice). A total of 22 credit points (ECTS) are earned.

The thematic elective areas of the supplementary studies are divided into the following 5 modules and their sub-topics:

Block 1Technology & Responsibility
Value change / ethics of responsibility, technology development / history of technology, general ecology, sustainability

Block 2Doing Culture
Cultural studies, cultural management, creative industries, cultural institutions, cultural policy

Block 3Media & Aesthetics
Media communication, cultural aesthetics

Block 4Spheres of Life
Cultural sociology, cultural heritage, architecture and urban planning, industrial science

Block 5Global Cultures
Multiculturalism / interculturalism / transculturalism, science and culture

Module grade calculation
The overall grade of the supplementary studies is calculated as an average of the grades of the examination performances weighted with credit points.

In-depth Module
- presentation 1 (3 ECTS)
- presentation 2 (3 ECTS)
- seminar paper incl. presentation (5 ECTS)
- oral examination (4 ECTS)
Annotation
With the Supplementary Studies on Culture and Society, KIT provides a multidisciplinary study offer as an additional qualification, with which the respective specialized study program is supplemented by interdisciplinary basic knowledge and interdisciplinary orientation knowledge in the field of cultural studies, which is becoming increasingly important for all professions.

Within the framework of the supplementary studies, students acquire in-depth knowledge of various cultural studies and interdisciplinary subject areas in the field of tension between culture, technology and society. In addition to high culture in the classical sense, other cultural practices, common values and norms as well as historical perspectives of cultural developments and influences are considered.

In the courses, conditions, procedures and concepts for the analysis and design of fundamental social development tasks are acquired on the basis of an expanded concept of culture. This includes everything created by humans - also opinions, ideas, religious or other beliefs. The aim is to develop a modern concept of cultural diversity. This includes the cultural dimension of education, science and communication as well as the preservation of cultural heritage. (UNESCO, 1982)

According to § 16 of the statutes, a reference and a certificate are issued by the ZAK for the supplementary studies. The achievements are also shown in the transcript of records of the degree program and, upon request, in the certificate. They can also be recognized in the interdisciplinary qualifications (see elective information).

Workload
The workload is made up of the recommended number of hours for the individual modules:

- basic module approx. 90 h
- in-depth module approx. 340 h
- practical module approx. 120 h

Total: approx. 550 h

Learning type
- lectures
- seminars
- workshops
- practical course

Literature
Recommended reading of primary and specialized literature will be determined individually by each instructor.
3.213 Module: Supplementary Studies on Sustainable Development [M-ZAK-106099]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation: Additional Examinations

<table>
<thead>
<tr>
<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Duration</th>
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<td>Each term</td>
<td>3 terms</td>
<td>German</td>
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</table>

**Election notes**

With the exception of the final oral exam, students have to self-record the achievements obtained in the Supplementary Studies on Sustainable Development in their study plan. ZAK records the achievements as “non-assigned” under “UQ/SQ-Leistungen”. Further instructions on self-recording of achievements can be found in the FAQ at [https://campus.studium.kit.edu/](https://campus.studium.kit.edu/) and on the ZAK homepage at [https://www.zak.kit.edu/begleitstudium-bene](https://www.zak.kit.edu/begleitstudium-bene). The title of the examination and the amount of credits override the modules placeholders.

If you want to use ZAK achievements both for your interdisciplinary qualifications and for the supplementary studies, please record them in the interdisciplinary qualifications first. You can then get in contact with the ZAK study services (stg@zak.kit.edu) to also record them in your supplementary studies.

In the elective module, you need to obtain 6 credits worth of achievements in two of the four areas:

- Sustainable Cities & Neighbourhoods
- Sustainable Assessment of Technology
- Subject, Body, Individual: The Other Side of Sustainability
- Sustainability in Culture, Economy & Society

Usually, two achievements with 3 credits each have to be obtained. To self-record achievements in the elective module, you first have to elect the matching partial achievement.

**Note:** If you registered for the Supplementary Studies on Sustainable Development before April 1st, 2023, self-recording an achievement in this module counts as a request in the sense of §19 (2) of the regulations for the Supplementary Studies on Sustainable Development. Your overall grade for the supplementary studies will thus be calculated as the average of the examination grades, not as the average of the module grades.

**Mandatory**

| T-ZAK-112345 | Basics Module - Self Assignment BeNe | 3 CR | Myglas |

**Elective Module (Elective: at least 6 credits)**

| T-ZAK-112347 | Elective Module - Sustainable Cities and Neighbourhoods - Self Assignment BeNe | 3 CR |
| T-ZAK-112348 | Elective Module - Sustainability Assessment of Technology - Self Assignment BeNe | 3 CR |
| T-ZAK-112349 | Elective Module - Subject, Body, Individual: The Other Side of Sustainability - Self Assignment BeNe | 3 CR |
| T-ZAK-112350 | Elective Module - Sustainability in Culture, Economy and Society - Self Assignment BeNe | 3 CR |

**Mandatory**

| T-ZAK-112346 | Specialisation Module - Self Assignment BeNe | 6 CR | Myglas |
| T-ZAK-112351 | Oral Exam - Supplementary Studies on Sustainable Development | 4 CR |
Competence Certificate
The monitoring is explained in the respective partial achievement.
They are composed of:
- protocols
- a reflection report
- presentations
- presentations
- the elaboration of a project work
- an individual term paper

Upon successful completion of the supplementary studies, graduates receive a graded report and a certificate issued by ZAK.

Prerequisites
The course is offered during the course of study and does not have to be completed within a defined period of time. Enrolment is required for all performance assessments of the modules of the supplementary studies. Participation in the supplementary studies is regulated by § 3 of the statutes.
KIT students register for the supplementary studies by selecting this module in the student portal and self-booking a performance. Registration for courses, performance assessments and examinations is regulated by § 6 of the Statutes and is usually possible shortly before the beginning of the semester.

The course catalogue, statutes (study regulations), registration form for the oral exam and guidelines for preparing the various written performance requirements can be found as downloads on the ZAK homepage at http://www.zak.kit.edu/begleitstudium-bene.

Competence Goal
Graduates of the supplementary studies in sustainable development acquire additional practical and professional competencies. Thus, the supplementary study program enables the acquisition of basics and initial experience in project management, trains teamwork skills, presentation skills and self-reflection, and also creates a fundamental understanding of sustainability that is relevant for all professional fields.
Graduates are able to analyse social topics and problem areas and critically reflect on them in a socially responsible and sustainable perspective. They are able to place the contents selected from the modules "Elective" and "Advanced" in the basic context as well as to independently and exemplarily analyse and evaluate the contents of the selected courses and to scientifically communicate about them in written and oral form.

Content
The supplementary study program Sustainable Development can be started from the 1st semester and is not limited in time. The wide range of courses offered by ZAK makes it possible to complete the program usually within three semesters. The supplementary studies comprise 19 credit points (LP). It consists of three modules: Basic Module, Elective Module and Advanced Module.
The thematical elective areas of the supplementary studies are divided into the following 4 modules and their subtopics in Module 2 (elective module):

Block 1  **Sustainable Cities and Neighbourhoods**
The courses provide an overview of the interaction of social, ecological, and economic dynamics in the microcosm of the city.

Block 2  **Sustainability Assessment of Technology**
mostly based on ongoing research activities, methods and approaches of technology assessment are elaborated.

Block 3  **Subject, Body, Individual: The other Side of Sustainability**
Different approaches are presented to the individual perception, experience, shaping and responsibility of relationships to the environment and to oneself.

Block 4  **Sustainability in Culture, Economy & Society**
Courses usually have an interdisciplinary approach, but may also focus on one of the areas of culture, economics or society, both in application and in theory.

The core of the supplementary studies is a case study in the specialization area. In this project seminar, students conduct sustainability research with practical relevance themselves. The case study is supplemented by an oral examination with two topics from module 2 (elective module) and module 3 (in-depth module).
Module grade calculation
The overall grade of the supplementary studies is calculated as an average of the grades of the examination performances weighted with credit points.

Elective module
- Presentation 1 (3 ECTS)
- Presentation 2 (3 ECTS)

Advanced module
- individual term paper (6 ECTS)
- oral examination (4 ECTS)

Annotation
The Supplementary Studies on Sustainable Development at KIT is based on the conviction that a long-term socially and ecologically compatible coexistence in the global world is only possible if knowledge about necessary changes in science, economy and society is acquired and applied.

The interdisciplinary and transdisciplinary Studies on Sustainable Development enables diverse access to transformation knowledge as well as basic principles and application areas of sustainable development. According to the statutes § 16, a certificate is issued by the ZAK for the complementary studies.

The achievements are also shown in the transcript of records of the degree program and, upon request, in the certificate. They can also be recognized in the interdisciplinary qualifications (see elective information). In the specialised studies, modules and partial achievements can be recognised within the framework of the additional achievements or e.g. the interdisciplinary qualifications. This must be regulated via the respective subject study programme.

The focus is on experience- and application-oriented knowledge and competences, but theories and methods are also learned. The aim is to be able to represent one's own actions as a student, researcher and later decision-maker as well as an individual and part of society under the aspect of sustainability.

Sustainability is understood as a guiding principle to which economic, scientific, social and individual actions should be oriented. According to this, the long-term and socially just use of natural resources and the material environment for a positive development of global society can only be addressed by means of integrative concepts. Therefore, “education for sustainable development” in the sense of the United Nations programme plays just as central a role as the goal of promoting “cultures of sustainability”. For this purpose, practice-centred and research-based learning of sustainability is made possible and the broad concept of culture established at ZAK is used, which understands culture as habitual behaviour, lifestyle and changing context for social actions.

The supplementary study programme conveys the basics of project management, trains teamwork skills, presentation skills and self-reflection. Complementary to the specialised studies at KIT, it creates a fundamental understanding of sustainability, which is important for all professional fields. Integrative concepts and methods are essential: in order to use natural resources in the long term and to shape the global future in a socially just way, not only different disciplines, but also citizens, practitioners and institutions must work together.

Workload
The workload is made up of the number of hours of the individual modules:

- Basic module approx. 180 h
- Elective module approx. 150 h
- Consolidation module approx. 180 h

Total: approx. 510 h

Learning type
- lectures
- seminars
- workshops

Literature
Recommended reading of primary and specialist literature is determined individually by the respective lecturer.
### 3.214 Module: Symmetric Encryption [M-INFO-100853]

**Responsible:** Prof. Dr. Jörn Müller-Quade  
**Organisation:** KIT Department of Informatics  
**Part of:** Complementary Field / Subject Computer Science

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<td>T-INF101390</td>
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</table>

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Mathematics Master 2016 (Master of Science (M.Sc.))  
Module Handbook as of 09/07/2024
### 3.215 Module: Technical Optics [M-ETIT-100538]

**Responsible:** Prof. Dr. Cornelius Neumann  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Complementary Field / Subject Electrical Engineering

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<th>Credits</th>
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<th>Recurrence</th>
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<td>Neumann</td>
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</table>

**Prerequisites**

none
3.216 Module: Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises [M-PHYS-102033]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics
Part of: Complementary Field / Subject Physics

Credits: 12
Grading scale: Grade to a tenth
Recurrence: Each winter term
Duration: 1 term
Language: English
Level: 4
Version: 1

Mandatory

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<th>T-PHYS-102544</th>
<th>Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises</th>
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<tr>
<td>12 CR</td>
<td>Heinrich, Melnikov, Mühlleitner, Nierste, Steinhauser</td>
</tr>
</tbody>
</table>

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102035 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises must not have been started.

Competence Goal
The student is introduced to the basic concepts of Relativistic Quantum Field Theory, masters the relevant theoretical concepts and can apply the computational methods. The student applies his/her knowledge to physical problems and can calculate simple processes of QED. The students deepen their knowledge in the exercises coordinated with the lecture.

Content
Classical field theory; Canonical quantization of boson, fermion and vector fields; Perturbation theory, Green's functions and Feynman diagrams; Calculation of effective cross sections; Quantum electrodynamics as gauge theory; Spontaneous symmetry breaking.

Workload
360 h consisting of attendance time (90 h), wrap-up of the lecture incl. exam preparation and working on the exercises (270 h)

Recommendation
Basic knowledge of electrodynamics, quantum mechanics and relativity (to the extent of Theory E).

Literature

- M. Peskin and D. Schroeder, An Introduction to Quantum Field Theory
- L. Ryder, Quantum Field Theory
Module: Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises [M-PHYS-102035]

Responsible:
Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation:
KIT Department of Physics
Part of: Complementary Field / Subject Physics

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<tr>
<th>Credits</th>
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<th>Recurrence</th>
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<th>Language</th>
<th>Level</th>
<th>Version</th>
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<td>8</td>
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<td>English</td>
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Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-102033 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises must not have been started.

Competence Goal
The student is introduced to the basic concepts of Relativistic Quantum Field Theory, masters the relevant theoretical concepts and can apply the computational methods. The student applies his/her knowledge to physical problems and can calculate simple processes of QED.

Content
Classical field theory; Canonical quantization of boson, fermion and vector fields; Perturbation theory, Green's functions and Feynman diagrams; Calculation of effective cross sections; Quantum electrodynamics as gauge theory; Spontaneous symmetry breaking.

Workload
240 h consisting of attendance time (60 h), wrap-up of lecture incl. exam preparation (180 h)

Recommendation
Basic knowledge of electrodynamics, quantum mechanics and relativity (to the extent of Theory E).

Literature
- M. Peskin and D. Schroeder, An Introduction to Quantum Field Theory.
- L. Ryder, Quantum Field Theory
Module: Theoretical Particle Physics II, with Exercises [M-PHYS-102046]

**M**

3.218 Module: Theoretical Particle Physics II, with Exercises [M-PHYS-102046]

**Responsible:**
Prof. Dr. Gudrun Heinrich  
Prof. Dr. Kirill Melnikov  
Prof. Dr. Milada Margarete Mühlleitner  
Prof. Dr. Ulrich Nierste

**Organisation:**
KIT Department of Physics

**Part of:**
Complementary Field / Subject Physics

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<td>English</td>
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</table>

**Mandatory**

| T-PHYS-102552 | Theoretical Particle Physics II, with Exercises | 12 CR | Heinrich, Melnikov, Mühlleitner, Nierste |

**Competence Certificate**

Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

**Prerequisites**

none

**Modeled Conditions**

The following conditions have to be fulfilled:

1. The module M-PHYS-102048 - Theoretical Particle Physics II, without Exercises must not have been started.

**Competence Goal**

Students know the basic concepts of non-Abelian gauge theories and their application in particle physics. They understand the underlying theoretical concepts and their interrelationships. The students know the standard model of particle physics and can handle the relevant computational methods. The students solve concrete problems of theoretical particle physics using the factual knowledge conveyed in the lecture.

**Content**

In the main part of the lecture, non-Abelian gauge theories and their application in elementary particle physics are discussed. The subject area includes the Lagrangian densities of QCD and the electroweak Standard Model as well as the Higgs mechanism. The Feynman rules that follow from the Lagrangian densities are introduced and applied in perturbation-theoretic calculations of rates for processes involving quarks and gluons. Regularization and renormalization of ultraviolet divergences are also treated, as well as applications of the renormalization group, the QCD beta function, and asymptotic freedom. Infrared divergences, parton distribution functions, and splitting functions are introduced.

**Workload**

360 hours consisting of attendance time (90 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (270 hours)

**Recommendation**

Theoretical Particle Physics I
Module: Theoretical Particle Physics II, without Exercises [M-PHYS-102048]

### Responsible:
Prof. Dr. Gudrun Heinrich  
Prof. Dr. Kirill Melnikov  
Prof. Dr. Milada Margarete Mühlleitner  
Prof. Dr. Ulrich Nierste

### Organisation:
KIT Department of Physics  
Part of: Complementary Field / Subject Physics

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**Competence Certificate**

Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

**Prerequisites**

none

**Modeled Conditions**

The following conditions have to be fulfilled:

1. The module M-PHYS-102046 - Theoretical Particle Physics II, with Exercises must not have been started.

**Competence Goal**

The students know the basic concepts of non-Abelian gauge theories and their application in particle physics. They understand the underlying theoretical concepts and their interrelationships. The students know the standard model of particle physics and can handle the relevant calculation methods.

**Content**

In the main part of the lecture, non-Abelian gauge theories and their application in elementary particle physics are discussed. The subject area includes the Lagrangian densities of QCD and the electroweak Standard Model as well as the Higgs mechanism. The Feynman rules that follow from the Lagrangian densities are introduced and applied in perturbation-theoretic calculations of rates for processes involving quarks and gluons. Regularization and renormalization of ultraviolet divergences are also treated, as well as applications of the renormalization group, the QCD beta function, and asymptotic freedom. Infrared divergences, parton distribution functions, and splitting functions are introduced.

**Workload**

240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation (180 hours)

**Recommendation**

Theoretical Particle Physics I
3.220 Module: Time Series Analysis [M-MATH-102911]

**Responsible:** PD Dr. Bernhard Klar  
**Organisation:** KIT Department of Mathematics  
**Part of:** Mathematical Methods 1 / Field Stochastics  
Mathematical Methods 2 / Field Stochastics  
Complementary Field / Field Stochastics  
Mathematical Specialization  
**Additional Examinations**

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</thead>
</table>

**Competence Certificate**
The module will be completed by an oral exam (ca. 20 min).

**Prerequisites**
None

**Competence Goal**
At the end of the course, students will

- know and understand the standard models of time series analysis,
- know exemplary statistical methods for model selection and model validation,
- independently apply models and methods from the lecture to real and simulated data,
- know specific mathematical techniques and be able to use them to analyze time series models.

**Content**
The lecture covers the basic concepts of classical time series analysis:

- Stationary time series
- Trends and seasonality
- Autocorrelation
- Autoregressive models
- ARMA models
- Parameter estimation
- Forecasting
- Spectral density and periodogram

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 120 hours  
Attendance: 45 hours

- lectures, problem classes, and examination

Self-studies: 75 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination
Recommendation
The contents of the course "Probability Theory" are strongly recommended. The contents of the course "Statistics" are recommended.
# 3.221 Module: Topological Data Analysis [M-MATH-105487]

**Responsible:** Prof. Dr. Tobias Hartnick
Prof. Dr. Roman Sauer

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Analysis
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Algebra and Geometry
- Complementary Field / Field Analysis
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

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**Mandatory**

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<th>T-MATH-111031</th>
<th>Topological Data Analysis</th>
<th>6 CR</th>
<th>Hartnick, Sauer</th>
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</thead>
</table>
3.222 Module: Topological Genomics [M-MATH-106064]

Responsible: Dr. Andreas Ott
Organisation: KIT Department of Mathematics
Part of:
- Mathematical Methods 1 / Field Algebra and Geometry
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 1 / Field Stochastics
- Mathematical Methods 2 / Field Algebra and Geometry
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Stochastics
- Complementary Field / Field Algebra and Geometry
- Complementary Field / Field Applied and Numerical Mathematics
- Complementary Field / Field Stochastics
- Mathematical Specialization
- Additional Examinations

<table>
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</table>

Competence Certificate

oral exam of ca. 20 min

Prerequisites

None

Module grade calculation

The grade of the module is the grade of the oral exam.

Workload

total workload: 90 hours
Module: Translation Surfaces [M-MATH-105973]

Responsible: Prof. Dr. Frank Herrlich
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Algebra and Geometry
Mathematical Methods 2 / Field Algebra and Geometry
Complementary Field / Field Algebra and Geometry
Mathematical Specialization
Additional Examinations

 Credits 8
Grading scale Grade to a tenth
Recurrence Irregular
Duration 1 term
Language German
Level 4
Version 1

Mandatory
T-MATH-112128 Translation Surfaces 8 CR Herrlich

Competence Certificate
The module will be completed by an oral exam of about 30 min.

Prerequisites
None

Competence Goal
At the end of the module, participants are able to

• name and discuss basic concepts to study translation surfaces,
• describe and use in examples essential methods for the classification of translation surfaces,
• read recent research papers on translation surfaces and write a thesis in this field.

Content

• Characterization of finite translation surfaces
• Riemann surfaces and algebraic curves
• Moduli space of Riemann surfaces
• Classification of translation surfaces
• Strata and the action of SL(2,R)
• Period coordinates

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours
Attendance: 90 hours

• lectures, problem classes, and examination

Self-studies: 150 hours

• follow-up and deepening of the course content,
• work on problem sheets,
• literature study and internet research relating to the course content,
• preparation for the module examination

Recommendation
Basic knowledge in surface topology and complex analysis is strongly recommended. The module “Algebraic Geometry” is also recommended.
3.224 Module: Traveling Waves [M-MATH-102927]

**Responsible:** Prof. Dr. Wolfgang Reichel  
**Organisation:** KIT Department of Mathematics  
**Part of:** Mathematical Methods 1 / Field Analysis  
Mathematical Methods 2 / Field Analysis  
Complementary Field / Field Analysis  
Mathematical Specialization

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**Mandatory**

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<tbody>
<tr>
<td></td>
<td>de Rijk, Reichel</td>
<td></td>
</tr>
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</table>

**Competence Certificate**

The module examination takes place in form of an oral exam of about 30 minutes. Please see under "Modulnote" for more information about the bonus regulation.

**Prerequisites**

none

**Competence Goal**

After successful completion of this module students:

- can explain the significance of traveling waves and their dynamic stability;
- know basic methods to study the existence of traveling waves;
- outline the main steps in a stability analysis and address potential complications;
- have acquired several mathematical tools to compute or approximate the spectrum;
- master several techniques to derive (in)stability of the wave from spectral information;
- understand how spectrum and stability might depend on the class of perturbations.

**Content**

Traveling waves are solutions to nonlinear partial differential equations (PDEs) that propagate over time with a fixed speed without changing their profiles. These special solutions arise in many applied problems where they model, for instance, water waves, nerve impulses in axons or light in optical fibers. Therefore, their existence and the naturally associated question of their dynamic stability is of interest, because only those waves which are stable can be observed in practice.

The first step in the stability analysis is to linearize the underlying PDE about the wave and compute the associated spectrum, which is in general a nontrivial task. To approximate spectra associated with various waves, such as fronts, pulses and periodic wave trains, we introduce the following tools:

- Sturm-Liouville theory
- exponential dichotomies
- Fredholm theory
- the Evans function
- parity arguments
- essential spectrum, point spectrum and absolute spectrum
- exponential weights

The next step is to derive useful bounds on the linear solution operator, or semigroup, based on the spectral information. A complicating factor is that any non-constant traveling wave possesses spectrum up to the imaginary axis. For various dissipative PDEs, such as reaction-diffusion systems, we employ the bounds on the linear solution operator to close a nonlinear argument via iterative estimates on the Duhamel formula. For traveling waves in Hamiltonian PDEs, such as the NLS or KdV equation, we describe a different route towards stability based on the variational arguments of Grillakis, Shatah and Strauss.

**Module grade calculation**

After passing the oral exam at the end of the semester, the final grade is \( \min(0.7X + 0.3Y, X) \), where \( X \) is the grade for the oral exam and \( Y \) is the grade obtained by voluntarily working out and presenting a model problem during one of the exercise classes.
Workload
Total workload: 180 hours
Attendance: 60 hours
  - lectures, problem classes, and examination
Self-studies: 120 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

Recommendation
The following background is strongly recommended: Analysis 1-4.

Literature
Module: Uncertainty Quantification [M-MATH-104054]

Responsible: Prof. Dr. Martin Frank
Organisation: KIT Department of Mathematics
Part of: Mathematical Methods 1 / Field Applied and Numerical Mathematics
Mathematical Methods 2 / Field Applied and Numerical Mathematics
Complementary Field / Field Applied and Numerical Mathematics
Mathematical Specialization
Additional Examinations

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<td>Uncertainty Quantification</td>
<td>4 CR</td>
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</table>

Prerequisites
None

Competence Goal
After successfully taking part in the module's classes and exams, students have gained knowledge and abilities as described in the "Inhalt" section.

Specifically, students know several parametrization methods for uncertainties. Furthermore, students are able to describe the basics of several solution methods (stochastic collocation, stochastic Galerkin, Monte-Carlo). Students can explain the so-called curse of dimensionality.

Students are able to apply numerical methods to solve engineering problems formulated as algebraic or differential equations with uncertainties. They can name the advantages and disadvantages of each method. Students can judge whether specific methods are applicable to the specific problem and discuss their results with specialists and colleagues. Finally, students are able to implement the above methods in computer codes.

Content
In this class, we learn to propagate uncertain input parameters through differential equation models, a field called Uncertainty Quantification (UQ). Given uncertain input (parameter values, initial or boundary conditions), how uncertain is the output? The first part of the course ("how to do it") gives an overview on techniques that are used. Among these are:

- Sensitivity analysis
- Monte-Carlo methods
- Spectral expansions
- Stochastic Galerkin method
- Collocation methods, sparse grids

The second part of the course ("why to do it like this") deals with the theoretical foundations of these methods. The so-called "curse of dimensionality" leads us to questions from approximation theory. We look back at the very standard numerical algorithms of interpolation and quadrature, and ask how they perform in many dimensions.

Recommendation
Numerical methods for differential equations
Module: Variational Methods [M-MATH-105093]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of:
- Mathematical Methods 1 / Field Analysis
- Mathematical Methods 2 / Field Analysis
- Complementary Field / Field Analysis
- Mathematical Specialization
- Additional Examinations

Credits: 8
Grading scale: Grade to a tenth
Recurrence: Irregular
Duration: 1 term
Level: 4
Version: 1

Mandatory

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<td>8 CR</td>
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</table>

Competence Certificate
The module will be completed by an oral exam (ca. 30 min).

Competence Goal
Graduates will be able to
- assess the significance of variational problems in relation to their applications in the natural sciences, engineering or geometry and illustrate them using examples,
- formulate variational problems independently,
- recognize the specific difficulties within the calculus of variations,
- analyze and solve concrete, prototypical problems,
- use techniques to prove the existence of solutions to certain classes of variational problems and calculate these solutions in special cases.

Content
- one-dimensional variational problems
- Euler-Lagrange equation
- necessary and sufficient criteria
- multidimensional variational problems
- direct methods of the calculus of variations
- existence of critical points of functionals

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours
Attendance: 90 hours
- lectures, problem classes, and examination
Self-studies: 150 hours
- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendation
The contents of the courses Functional Analysis, Classical Methods for Partial Differential Equations, or Boundary and Eigenvalue problems are recommended.
3.227 Module: Wavelets [M-MATH-102895]

**Responsible:** Prof. Dr. Andreas Rieder

**Organisation:** KIT Department of Mathematics

**Part of:**
- Mathematical Methods 1 / Field Applied and Numerical Mathematics
- Mathematical Methods 2 / Field Applied and Numerical Mathematics
- Complementary Field / Field Applied and Numerical Mathematics
- Mathematical Specialization
- Additional Examinations

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</table>

**Competence Certificate**
Success is assessed in the form of an oral examination lasting approx. 30 minutes.

**Prerequisites**
none

**Competence Goal**
Graduates are able

- to name, discuss and analyze the functional-analytical principles of continuous and discrete wavelet transforms,
- to apply the wavelet transform as an analysis tool in signal and image processing and evaluate the results obtained,
- to explain design aspects for wavelet systems.

**Content**

- Short-time Fourier transform
- Integral wavelet transform
- Wavelet frames
- Wavelet basis
- Fast wavelet transform
- Construction of orthogonal and bi-orthogonal wavelet systems
- Applications in signal and image processing

**Module grade calculation**
The module grade is the grade of the oral exam.

**Workload**
Total workload: 240 hours

- Attendance: 90 hours
  - lectures, problem classes, and examination
- Self-studies: 150 hours
  - follow-up and deepening of the course content,
  - work on problem sheets,
  - literature study and internet research relating to the course content,
  - preparation for the module examination

**Recommendation**
The course “Functional analysis” is recommended.
## 3.228 Module: Wildcard [M-MATH-103198]

**Organisation:** University  
**Part of:** Complementary Field / Subject Mechanical Engineering

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| T-MATH-106331 | Wildcard 1 | 6 CR |

**Prerequisites**  
None
4 Courses

4.1 Course: Adaptive Finite Element Methods [T-MATH-105898]

Responsible: Prof. Dr. Willy Dörfler
Organisation: KIT Department of Mathematics
Part of: M-MATH-102900 - Adaptive Finite Elemente Methods

<table>
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Events

| ST 2024 | 0160610 | Tutorial for 0160600 (Numerical Methods in Fluidmechanics) | 1 SWS | Practice | Dörfler |

Prerequisites
none
4.2 Course: Advanced Corporate Finance [T-WIWI-113469]

**Responsible:** Prof. Dr. Martin Ruckes

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101480 - Finance 3
- M-WIWI-101483 - Finance 2
- M-WIWI-101502 - Economic Theory and its Application in Finance

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**Events**

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<td>Lecture / 📏</td>
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**Exams**

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<th>Title</th>
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<th>Language</th>
<th>Credits</th>
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<tbody>
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<td>Lecture / 📏</td>
<td>English</td>
<td>2 SWS</td>
<td>Grade to a third</td>
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</table>

**Competence Certificate**
The assessment of this course is a written examination (following §4(2), 1 SPO) of 60 mins. The exam is offered each semester.

**Below you will find excerpts from events related to this course:**

**Advanced Corporate Finance**

2530214, SS 2024, 2 SWS, Language: English, Open in study portal

**Content**
The course covers the foundational principles of advanced topics of corporate finance, such as corporate governance, executive compensation, strategy & finance, mergers & acquisitions (M&A), and sustainable finance. Additionally, the course explores the respective institutional aspects within these areas of corporate finance. The approach is holistic, including both theoretical-conceptual aspects (e.g., moral hazard and the influence of asymmetric information) and empirical insights (e.g., the effects of financial decisions on firm value). Throughout, the course will emphasize both fundamental and current research findings.

**Learning outcomes:**
Upon successful completion of the course, students will possess profound knowledge and skills in advanced areas of corporate finance. These areas include topics such as corporate governance, executive compensation, strategy and finance, mergers and acquisitions (M&A), as well as key aspects of sustainable finance. Participants of this course will be able to describe and analyze the theoretical and conceptual foundations of the effects of information asymmetries and moral hazard on corporate financing behavior and assess their impact in corporate practice. Furthermore, upon completion of the course, participants will be familiar with the fundamental institutional elements in these areas and be able to discuss and solve advanced problems in corporate finance from both a theoretical and an empirical perspective. Moreover, students will acquire an advanced understanding of the central scientific findings in these topic areas, which will enable them to critically apply them in scientific and practical contexts.

**Literature**

Various source of literature, among others Brealey/Myers/Allen/Edmans: Principles of Corporate Finance; Thomson/Conyon: Corporate Governance: Mechanisms and Systems; Larcker/Tayan: Corporate Governance Matters. Additional reading materials will be introduced during the course.
4.3 Course: Advanced Empirical Asset Pricing [T-WIWI-110513]

| Responsible: | TT-Prof. Dr. Julian Thimme |
| Organisation: | KIT Department of Economics and Management |
| Part of: | M-WIWI-101480 - Finance 3  
M-WIWI-101483 - Finance 2 |

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<td>Each winter term</td>
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</table>

**Exams**

| ST 2024 | 7900321 | Advanced Empirical Asset Pricing | Thimme |
| WT 24/25 | 7900319 | Advanced Empirical Asset Pricing | Thimme |

**Competence Certificate**

The success control takes place in form of a written examination (60 min) during the semester break. If the number of participants is low, an oral examination may also be offered. The examination is offered every semester and can be repeated at any regular examination date.

A bonus can be acquired by submitting exercise solutions to 80% of the assigned exercise tasks. If the grade of the written examination is between 4.0 and 1.3, the bonus improves the grade by up to one grade level (0.3 or 0.4). Details will be announced in the lecture.

**Recommendation**

We strongly recommend knowledge of the basic topics in investments (bachelor course), which will be necessary to be able to follow the course. In addition, prior participation in the Asset Pricing Master course is strongly recommended.

**Annotation**

New course from winter semester 2019/2020.
4 COURSES

4.4 Course: Advanced Game Theory [T-WIWI-102861]

**Responsible:** Prof. Dr. Karl-Martin Ehrhart
Prof. Dr. Clemens Puppe
Prof. Dr. Johannes Philipp Reiß

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101500 - Microeconomic Theory
- M-WIWI-101502 - Economic Theory and its Application in Finance
- M-WIWI-102970 - Decision and Game Theory

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<td>Grade to a third</td>
<td>Each winter term</td>
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</table>

**Competence Certificate**
The assessment consists of a written exam (60 minutes) (following §4(2), 1 of the examination regulation). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

**Prerequisites**
None

**Recommendation**
Basic knowledge of mathematics and statistics is assumed.

**Below you will find excerpts from events related to this course:**

- **Advanced Game Theory**
  - Code: 2500037, WS 24/25, 2 SWS, Language: English, [Open in study portal](#)
  - Lecture (V) On-Site

- **Übung zu Advanced Game Theory**
  - Code: 2500038, WS 24/25, 1 SWS, Language: English, [Open in study portal](#)
  - Practice / 🗺 Puppe, Ammann
4.5 Course: Advanced Inverse Problems: Nonlinearity and Banach Spaces [T-MATH-105927]

**Responsible:** Prof. Dr. Andreas Rieder

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102955 - Advanced Inverse Problems: Nonlinearity and Banach Spaces

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**Prerequisites**

none
4.6 Course: Advanced Lab Blockchain Hackathon (Master) [T-WIWI-111126]

**Responsible:** Prof. Dr. Ali Sunyaev

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101472 - Informatics

<table>
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<td>Each term</td>
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</table>

**Exams**

| ST 2024 | 7900172 | Lab Blockchain Hackathon (Master) | Sunyaev |

**Competence Certificate**

The alternative exam assessment consists of:

- a practical work
- a presentation and
- a written seminar thesis

Practical work, presentation and written thesis are weighted according to the course.

**Prerequisites**

None
### 4.7 Course: Advanced Lab Informatics (Master) [T-WIWI-110548]

**Responsible:** Professorenschaft des Instituts AIFB  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics

<table>
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#### Events

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<td>Lab Automation in Everyday Life (Master)</td>
<td>3 SWS</td>
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<td>Schiefer, Schüler, Toussaint</td>
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#### Exams

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<td>7900178</td>
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**Legend:** 🌐 Online, ☒ Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

### Competence Certificate

The alternative exam assessment consists of:

- a practical work
- a presentation and
- a written seminar thesis

Practical work, presentation and written thesis are weighted according to the course.
Prerequisites
None

Annotation
The title of this course is a generic one. Specific titles and the topics of offered seminars will be announced before the start of a semester in the internet at https://portal.wiwi.kit.edu.

Below you will find excerpts from events related to this course:

**Lab Realisation of innovative services (Master)**
2512205, SS 2024, 3 SWS, Language: German, Open in study portal

Content
As part of the lab, the participants should work together in small groups to realize innovative services (mainly for students).

Organizational issues
Informationen zu Themen und die Anmeldung erfolgt vor Praktikumsbeginn im Wiwi-Portal https://portal.wiwi.kit.edu/ys

**Lab Automation in Everyday Life (Master)**
2512207, SS 2024, 3 SWS, Language: German, Open in study portal

Content
As part of the lab, various topics on everyday automation are offered. During the lab, the participants will gain an insight into problem-solving oriented project work and work on a project together in small groups.

In case of questions, please contact fabian.rybinski@kit.edu.

Organizational issues
Informationen zu Themen und die Anmeldung erfolgt vor Praktikumsbeginn im Wiwi-Portal https://portal.wiwi.kit.edu/ys

Bei Fragen bitte an fabian.rybinski@kit.edu wenden.

**Advanced Lab Development of Sociotechnical Information Systems (Master)**
2512401, SS 2024, 3 SWS, Language: German/English, Open in study portal

Content
The aim of the lab is to get to know the development of socio-technical information systems in different application areas. In the event framework, you should develop a suitable solution strategy for your problem alone or in group work, collect requirements, and implement a software artifact based on it (for example, web platform, mobile apps, desktop application). Another focus of the lab is on the subsequent quality assurance and documentation of the implemented software artifact.

Registration information will be announced on the course page.

**Project Lab Machine Learning**
2512500, SS 2024, 3 SWS, Language: German/English, Open in study portal
Content
The lab is intended as a practical supplement to lectures such as “Machine Learning”. The theoretical basics are applied in the lab course. The aim of the lab course is that the participants work together to design, develop and evaluate a subsystem from the field of robotics and cognitive systems using one or more procedures from the field of AI/ML.

In addition to the scientific objectives involved in the investigation and application of the methods, aspects of project-specific teamwork in research (from specification to presentation of the results) are also developed in this practical course. The individual projects require the analysis of the task at hand, selection of suitable procedures, specification and implementation and evaluation of the approach taken. Finally, the chosen solution has to be documented and presented in a short presentation.

Learning objectives:
- Students can practically apply knowledge from the Machine Learning lecture in a selected field of current research in robotics or cognitive automobiles.
- Students master the analysis and solution of corresponding problems in a team.
- Students can evaluate, document and present their concepts and results.

Recommendations:
Attendance of the lecture machine learning, C/C++ knowledge, Python knowledge

Workload:
The workload of 5 credit points consists of the time spent in the lab for practical implementation of the selected solution, as well as the time spent on literature research and planning/specifying the proposed solution. In addition, a short report and a presentation of the work carried out will be prepared.

Organizational issues
Anmeldung und weitere Informationen sind im WiWi-Portal zu finden.

Registration and further information can be found in the WiWi-portal.
Content
The Praktikum Security, Usability and Society will cover topics both of usable security and privacy programming, and how to conduct user studies. To reserve a place, please, register on the WiWi portal and send an email with your chosen topic, plus a back-up one, to mattia.mossano@kit.edu. Topics are assigned first-come-first-served until all of them are filled. Topics in italics have been already assigned.

Application deadline 12.04.2024
Assignment 15.04.2024
Confirmation deadline 19.04.2024

Important dates:
Kick-off: 17.04.2024, 09:00 AM CET in Big Blue Button - Link
Report & code feedback deadline: 26.07.2024, 23:59 CET
Feedback on Report & code: 16.08.2024, 23:59 CET
Final report + code deadline: 01.09.2024, 23:59 CET
Presentation draft deadline: 06.09.2024, 23:59 CET
Feedback on presentation draft: 13.09.2024, 23:59 CET
Final presentation deadline: 17.09.2024, 23:59 CET
Presentation day: 18.09.2024, 09:00 CET

Topics:

Privacy Friendly Apps
In this area, students complete an app (or an extension of an app) among our Privacy-Friendly Apps. Please click the following link to know more about them: https://secuso.aifb.kit.edu/english/105.php. Students are provided with a point list of goals, containing both basic features mandatory to pass the course and more advanced ones that heighten the final grade.
Title: NoPhish App
Number of students: 2 Ba/Ma
Description: The NoPhish app was one of the first measures from the NoPhish concept. The app has been around for a long time and has not been updated since then. Accordingly, the task of the project is to make the app functional for the current Android version. The app is also to be optimised so that updates, e.g. new chapters, can be added easily.

Programming Usable Security Intervention
In this subject, students develop a part of coding, an extension, or another programming task dealing with various usable security interventions, eg as an extension. Eg TORPEDO (https://secuso.aifb.kit.edu/english/TORPEDO.php) or PassSec + (https://secuso.aifb.kit.edu/english/PassSecPlus.php). Just as before, students are provided with a point list of goals, containing both basic features mandatory to pass the course and more advanced ones that heighten the final grade.
Title: Hacking TORPEDO
Number of students: 1-2 Ba/Ma
Description: TORPEDO has existed for many years both as a Thunderbird add-on and as a web extension. TORPEDO is intended to help address various forms of phishing attacks and thereby protect the user, e.g. against various manipulations of the domain or additional tooltips. However, no targeted attacks on TORPEDO have yet been found. The aim of the work is to subject TORPEDO to a stress test and also to develop attacks that specifically target the implementation of TORPEDO.
Title: Making e-mails more visible by embedding moving images
Number of students: 1 Ma
Description: In case of a security incident, it is necessary to inform the affected persons about their vulnerabilities as soon as possible. Within the context of the INSPECTION project, we are currently informing website owners via e-mail about security related vulnerabilities on their websites. Although e-mails have been shown to be the most cost-efficient means to deliver such information, they have not lead to an appropriate remediation rate. While speaking to the affected website owners we learned that they would appreciate more information, although not being delivered as more text in the e-mail. Also, we learned that most e-mails were not read because they were considered spam. Thus, we need to find a way to make e-mail notifications more effective in raising peoples’ awareness. Videos have been proven effective to raise awareness in the context of IT security. The goal of the project will be, to explore ways to embed videos in an e-mail via HTML (either as gifs or as preview to a YouTube video). The challenge is to make this e-mail readable for different clients and webmail as well as getting it delivered through spam filters.

Designing Security User studies
These topics are related to how to set up and conduct user studies of various types. Online studies, interviews and lab studies are possible. At the end of the semester, the students present a report / paper and a talk in which they present their methodologies and the results of small pre-studies.
Title: Usability of Password Managers in Virtual Reality  
Number of students: 2 Ma  
Description: The pre-dominant form of authentication in Virtual Reality (VR) are passwords. Passwords create a burden for users in the VR environment because of special input methods and the virtual keyboard [Stephenson, S. et al (2022). Sok: Authentication in Augmented and Virtual Reality]. Password Managers (PMs) can support the user with handling this problem [Mayer, P. et al. (2022). Why Users (Don't) Use Password Managers at a Large Educational Institution]. They offer auto-filling features, store credentials in an overview or generate complex and secure passwords. Especially in the VR context, where typing a password is slow and complex, PMs can be beneficial. We want to explore the different PMs in VR and test the usability to find challenges and possible solutions.

Run Usable Security Studies and Results Analysis  
These topics are related to run and analyse the results of user-studies. Online studies, interviews and lab studies are all possible, depending on the topic. At the end of the semester, the students present a report / paper with the analyses conducted and a talk in which they present the results.

Title: Visualization of Eye Gaze Patterns during Authentication Tasks  
Number of students: 1 Ba/Ma  
Description: In this project, students will analyze and visualize eye gaze data collected during two specific authentication tasks: the Dot Task and the Slider Task. The primary objective is to represent subjects' eye movements visually, enhancing the understanding of gaze patterns during the authentication process. *Dot Task Visualization:* For the Dot Task, participants were instructed to focus on a sequence of dots displayed on a screen. The dataset includes the positions of these dots and the corresponding gaze locations of the subjects. The student's task is to create a dynamic visualization that not only represents these positions accurately but also illustrates the sequence in which the dots were focused on by the subjects. *Slider Task Visualization:* The Slider Task involved presenting participants with a series of images, for which both the images' locations on the screen and the subjects' gaze locations are recorded. The challenge is to develop a heatmap visualization based on this data, effectively demonstrating the concentration and dispersion of gaze points across different images.

Title: How do website owners become aware that their website was hacked?  
Number of students: 1 Ma  
Description: We identified website owners that were affected by a hack on their website and sent them a notification. During the course of the notification process, we also identified several websites that seemingly remediated the hack before our notification. We now wanted to find out, how those website owners got aware of the hack. If they were notified by a third party, we would also like to know how and by whom they were notified and what their feelings were with respect to the notification. To answer these questions, a survey was designed and pre-tested with a sample of website owners. The study was run as an online survey using SocSciSurvey. The aim of this lab topic will be to improve the survey based on the findings of the pre-study (https://publikationen.bibliothek.kit.edu/1000160718) and sent out invitations to the survey to around 100 website owners.

Title: Phishing through homographic attacks in messengers and social networks  
Number of students: 1-2 Ba/Ma  
Description: The task will be to test three types of attacks in messengers and social networks that work in some email clients. First is the link mismatch attack, where the link text differs from the actual link target. Second is an attack in which the actual link target is disguised by URL encoding [https://en.wikipedia.org/wiki/URL_encoding], and finally homographic attacks which uses Internationalized Domain Names [https://en.wikipedia.org/wiki/IDN_homograph_attack], in which Latin characters are replaced by characters of a different alphabet in the domain name. The attacks are predefined, so no knowledge of phishing techniques is required.

Title: Usability Study of Mobile Authentication for Elderly Users with Rheumatoid Arthritis (English only)  
Number of students: 1 Ba/Ma  
Description: Authentication is an ever important topic, especially in the mobile context. However, it becomes even more relevant when considering accessibility to it. Nowadays, a common authentication method is using a PIN. Yet, given the low hand mobility of users affected by rheumatoid arthritis, sometimes using PINs can be difficult. In this topic, the student will conduct several sessions of an already designed lab study with various participants using arthritis simulation gloves to evaluate three PIN-pad interfaces aimed at making authentication more accessible. The study will also investigate the preferences of users regarding PIN-pad interfaces through drawings and proposals of changes. The student will then analyze the results through inferential statistics. Depending on the quality of the outcome, the results will then be published in a paper and the student will be added to the authors list.

This event counts towards the KASTEL certificate. Further information on how to obtain the certificate can be found on the SECUSO website (https://secuso.aifb.kit.edu/Studium_und_Lehre.php).

Content  
As part of the lab, the participants should work together in small groups to realize innovative services (mainly for students).
Organizational issues
Informationen zu Themen und die Anmeldung erfolgt vor Praktikumsbeginn im Wiwi-Portal
https://portal.wiwi.kit.edu/ys

Practical Course Linked Data and the Semantic Web (Master)
2512314, WS 24/25, 3 SWS, Language: German/English, Open in study portal

Content
Linked Data is a way of publishing data on the web in a machine-understandable fashion. The aim of this practical seminar is to build applications and devise algorithms that consume, provide, or analyse Linked Data.

The Linked Data principles are a set of practices for data publishing on the web. Linked Data builds on the web architecture and uses HTTP for data access, and RDF for describing data, thus aiming towards web-scale data integration. There is a vast amount of data available published according to those principles: recently, 4.5 billion facts have been counted with information about various domains, including music, movies, geography, natural sciences. Linked Data is also used to make web-pages machine-understandable, corresponding annotations are considered by the big search engine providers. On a smaller scale, devices on the Internet of Things can also be accessed using Linked Data which makes the unified processing of device data and data from the web easy.

In this practical seminar, students will build prototypical applications and devise algorithms that consume, provide, or analyse Linked Data. Those applications and algorithms can also extend existing applications ranging from databases to mobile apps.

For the seminar, programming skills or knowledge about web development tools/technologies are highly recommended. Basic knowledge of RDF and SPARQL are also recommended, but may be acquired during the seminar. Students will work in groups. Seminar meetings will take place as ‘Block-Seminar’.

Topics of interest include, but are not limited to:
- Travel Security
- Geo data
- Linked News
- Social Media

The exact dates and information for registration will be announced at the event page.

Practical Course Cognitive automobiles and robots (Master)
2512501, WS 24/25, 3 SWS, Language: German/English, Open in study portal

Content
The lab is intended as a practical supplement to courses such as "Machine Learning 1/2". Scientific topics, mostly in the area of autonomous driving and robotics, will be addressed in joint work with ML/KI methods. The goal of the internship is for participants to design, develop, and evaluate ML Software system.

In addition to the scientific goals, such as the study and application of methods, the aspects of project-specific teamwork in research (from specification to presentation of results) are also worked on in this internship.

The individual projects require the analysis of the set task, selection of appropriate methods, specification and implementation and evaluation of the solution approach. Finally, the selected solution is to be documented and presented in a short lecture.

Learning Objectives:
- Students will be able to practically apply theoretical knowledge from lectures on machine learning to a selected area of current research.
- Students will be proficient in analyzing and solving thematic problems.
- Students will be able to evaluate, document, and present their concepts and results.

Recommendations:
- Theoretical knowledge of machine learning and/or AI.
- Python knowledge
- Initial experience with deep learning frameworks such as PyTorch/Jax/Tensorflow may be beneficial.

Workload:
The workload of 5 credit points consists of practical implementation of the selected solution, as well as time for literature research and planning/specification of the selected solution. In addition, a short report and presentation of the work performed will be prepared.
Organizational issues
Anmeldung und weitere Informationen sind im Wiwi-Portal zu finden.
Registration and further information can be found in the WiWi-portal.
4.8 Course: Advanced Lab Realization of Innovative Services (Master) [T-WIWI-112914]

Responsible: Prof. Dr. Andreas Oberweis
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

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Exams

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

Competence Certificate
The alternative exam assessment consists of:

- a practical work
- a presentation and
- a written seminar thesis

Practical work, presentation and written thesis are weighted according to the course.

Annotation
As part of the lab, the participants should work together in small groups to produce innovative services (mainly for students).

Further information can be found on the ILIAS page of the lab.

Below you will find excerpts from events related to this course:

Lab Realisation of innovative services (Master)
2512205, SS 2024, 3 SWS, Language: German, Open in study portal

Practical course (P)
On-Site

Content
As part of the lab, the participants should work together in small groups to realize innovative services (mainly for students).

Organizational issues
Informationen zu Themen und die Anmeldung erfolgt vor Praktikumsbeginn im Wiwi-Portal
https://portal.wiwi.kit.edu/ys

Lab Realisation of innovative services (Master)
2512205, WS 24/25, 3 SWS, Language: German, Open in study portal

Practical course (P)
Blended (On-Site/Online)

Content
As part of the lab, the participants should work together in small groups to realize innovative services (mainly for students).

Organizational issues
Informationen zu Themen und die Anmeldung erfolgt vor Praktikumsbeginn im Wiwi-Portal
https://portal.wiwi.kit.edu/ys
4.9 Course: Advanced Lab Security [T-WIWI-109786]

**Responsible:** Prof. Dr. Melanie Volkamer

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101472 - Informatics

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**Competence Certificate**

The alternative exam assessment consists of:

- a practical work
- a presentation and possibly
- a written seminar thesis

Practical work, presentation and written thesis are weighted according to the course.

**Prerequisites**

None

**Recommendation**

Knowledge from the lecture "Information Security" is recommended.

**Annotation**

Form of teaching and learning: Advanced lab
4.10 Course: Advanced Lab Security, Usability and Society [T-WIWI-108439]

**Responsibility:** Prof. Dr. Melanie Volkamer

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101472 - Informatics

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**Exams**

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**Legend:** 🌐 Online, 🛏️ Blended (On-Site/Online), 🗣 On-Site, 🗑 Cancelled

**Competence Certificate**

The alternative exam assessment consists of:

- a practical work
- a presentation and possibly
- a written seminar thesis

Practical work, presentation and written thesis are weighted according to the course.

**Prerequisites**

None

**Recommendation**

Knowledge from the lecture "Information Security" is recommended.

**Annotation**

The course will not be offered in the summer semester 2023.

**Below you will find excerpts from events related to this course:**

**Practical lab Security, Usability and Society (Bachelor)**

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<td>3 SWS</td>
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Content

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Presentation draft deadline: 06.09.2024, 23:59 CET
Feedback on presentation draft: 13.09.2024, 23:59 CET
Final presentation deadline: 17.09.2024, 23:59 CET
Presentation day: 18.09.2024, 09:00 CET

Topics:

Privacy Friendly Apps

In this area, students complete an app (or an extension of an app) among our Privacy-Friendly Apps. Please click the following link to know more about them: https://secuso.aifb.kit.edu/english/105.php. Students are provided with a point list of goals, containing both basic features mandatory to pass the course and more advanced ones that heighten the final grade.

Title: NoPhish App
Number of students: 2 Ba/Ma
Description: The NoPhish app was one of the first measures from the NoPhish concept. The app has been around for a long time and has not been updated since then. Accordingly, the task of the project is to make the app functional for the current Android version. The app is also to be optimised so that updates, e.g. new chapters, can be added easily.

Programming Usable Security Intervention

In this subject, students develop a part of coding, an extension, or another programming task dealing with various usable security interventions, e.g. as an extension like TORPEDO (https://secuso.aifb.kit.edu/english/TORPEDO.php) or PassSec+ (https://secuso.aifb.kit.edu/english/PassSecPlus.php). Just as before, students are provided with a point list of goals, containing both basic features mandatory to pass the course and more advanced ones that heighten the final grade.

Title: Hacking TORPEDO
Number of students: 1-2 Ba/Ma
Description: TORPEDO has existed for many years both as a Thunderbird add-on and as a web extension. TORPEDO is intended to help address various forms of phishing attacks and thereby protect the user, e.g. against various manipulations of the domain or additional tooltips. However, no targeted attacks on TORPEDO have yet been found. The aim of the work is to subject TORPEDO to a stress test and also to develop attacks that specifically target the implementation of TORPEDO.

Run Usable Security Studies and Results Analysis

These topics are related to run and analyse the results of user-studies. Online studies, interviews and lab studies are all possible, depending on the topic. At the end of the semester, the students present a report / paper with the analyses conducted and a talk in which they present the results.

Title: Visualization of Eye Gaze Patterns during Authentication Tasks
Number of students: 1 Ba/Ma
Description: In this project, students will analyze and visualize eye gaze data collected during two specific authentication tasks: the Dot Task and the Slider Task. The primary objective is to represent subjects’ eye movements visually, enhancing the understanding of gaze patterns during the authentication process. *Dot Task Visualization:* For the Dot Task, participants were instructed to focus on a sequence of dots displayed on a screen. The dataset includes the positions of these dots and the corresponding gaze locations of the subjects. The student's task is to create a dynamic visualization that not only represents these positions accurately but also illustrates the sequence in which the dots were focused on by the subjects. *Slider Task Visualization:* The Slider Task involved presenting participants with a series of images, for which both the images' locations on the screen and the subjects' gaze locations are recorded. The challenge is to develop a heatmap visualization based on this data, effectively demonstrating the concentration and dispersion of gaze points across different images.
Title: Compare BSI Phishing Game with the NoPhish Game
Number of students: 1 Ba
Description: The NoPhish app, one of the first implementations of the NoPhish concept, is a form of serious game. The BSI has also developed a game in the field of phishing. Both "games" use different approaches to impart knowledge from the same context. The aim is to evaluate the two games in terms of similarities and differences.

Title: Phishing Advice from Organizations (English Only)
Number of students: 1 Ba
Description: Many companies distribute information on how to recognise phishing via various channels such as e-mails, e.g. Amazon or Telekom. The question arises as to how helpful these tips are in reality. Are they too specific to the context of the company or so abstractly formulated that they are of no real help to users? The aim of the work is to collect various hints and then compare them with the hints of the NoPhish concept in order to find differences and similarities between the hints and the concept.

Title: Chatbots for Literature Reviews
Number of students: 1 Ba
Description: Chatbots are becoming increasingly popular and are already being used in various areas. But in what form can these bots be used for science? The variety of chatbots also raises the question of whether there are chatbots that are better suited to a scientific context. The aim is to identify a selection of chatbots and evaluate them in terms of their effectiveness for future literature research. To this end, the results of the chatbots will be compared with the ACM database in order to check their effectiveness for finding literature for a specific period of time.

Title: Phishing through homographic attacks in messengers and social networks
Number of students: 1-2 Ba/Ma
Description: The task will be to test three types of attacks in messengers and social networks that work in some email clients. First is the link mismatch attack, where the link text differs from the actual link target. Second is an attack in which the actual link target is disguised by URL encoding [https://en.wikipedia.org/wiki/URL_encoding], and finally homographic attacks which uses Internationalized Domain Names [https://en.wikipedia.org/wiki/IDN_homograph_attack], in which Latin characters are replaced by characters of a different alphabet in the domain name. The attacks are predefined, so no knowledge of phishing techniques is required.

Title: Usability Study of Mobile Authentication for Elderly Users with Rheumatoid Arthritis (English only)
Number of students: 1 Ba/Ma
Description: Authentication is an ever important topic, especially in the mobile context. However, it becomes even more relevant when considering accessibility to it. Nowadays, a common authentication method is using a PIN. Yet, given the low hand mobility of users affected by rheumatoid arthritis, sometimes using PINs can be difficult. In this topic, the student will conduct several sessions of an already designed lab study with various participants using arthritis simulation gloves to evaluate three PIN-pad interfaces aimed at making authentication more accessible. The study will also investigate the preferences of users regarding PIN-pad interfaces through drawings and proposals of changes. The student will then analyse the results through inferential statistics. Depending on the quality of the outcome, the results will then be published in a paper and the student will be added to the authors list.

This event counts towards the KASTEL certificate. Further information on how to obtain the certificate can be found on the SECUSO website (https://secuso.aifb.kit.edu/Studium_und_Lehre.php).

Praktikum Security, Usability and Society (Bachelor)
2512554, WS 24/25, 3 SWS, Language: German/English, Open in study portal
Practical course (P)
Blended (On-Site/Online)
Content
The Praktikum Security, Usability and Society will cover topics both of usable security and privacy programming, and how to conduct user studies. To reserve a place, please, register on the WiWi portal and send an email with your chosen topic, plus a back-up one, to mattia.mossano@kit.edu. Topics are assigned first-come-first-served until all of them are filled. Topics in italics have already been assigned.

There are two rounds to apply:
**Summer round closes** on 16.07.2023. Assignment will be done by 17.07.2023 and confirmation must be received by 21.07.2023. **Autumn round opens** 11.09.2023 and closes on 08.10.2023. Assignment will be done by 09.10.2023 and confirmation must be received by 13.10.2023.

Important dates:
- **Kick-off:** 05.10.2023, 09:00 AM CET in Big Blue Button - [Link](#)
- **Report & code feedback deadline:** 01.03.2024, 23:59 CET
- **Feedback on Report & code:** 08.03.2024, 23:59 CET
- **Final report + code deadline:** 15.03.2024, 23:59 CET
- **Presentation draft deadline:** 15.03.2024, 23:59 CET
- **Feedback on presentation draft:** 19.03.2024, 23:59 CET
- **Final presentation deadline:** 22.03.2024, 23:59 CET
- **Presentation day:** 29.03.2024, 09:00 CET

Topics:

Privacy Friendly apps
In this subject, students complete an app (or an extension of an app) among our Privacy-Friendly Apps. Please click the following link to know more about them: [https://seecuso.aifb.kit.edu/english/105.php](https://seecuso.aifb.kit.edu/english/105.php). Students are provided with a point list of goals, containing both basic features mandatory to pass the course and more advanced ones that heighten the final grade.

- **Title:** Notes 2.0
- **Number of students:** 1 Bachelor
- **Description:** Update und Vorbereitung zur Veröffentlichung der Notes 2.0-App.

Designing Security User studies
These topics are related to how to set up and conduct user studies of various types. Online studies, interviews and lab studies are possible. At the end of the semester, the students present a report / paper and a talk in which they present their methodologies and the results of small pre-studies.

- **Title:** Designing User Studies for Evaluating Biometric Authentication Systems
- **Number of students:** 1 Bachelor or Master level
- **Description:** The proposed topic focuses on designing and implementing a user study methodology to evaluate the usability and user perception of biometric authentication systems. Biometric authentication involves using unique physiological or behavioral characteristics, such as fingerprints, facial recognition, or voice patterns, to verify a user's identity. The goal of this research is to understand the factors that affect the effectiveness and acceptance of biometric authentication and provide insights for designing user-friendly and secure biometric authentication systems.

- **Title:** How useful are security advice given by ChatGPT?
- **Number of students:** 1-2 Bachelor level
- **Description:** ChatGPT is nowadays used for multiple reasons. One of them is to obtain advice on security decision, asking the program how to best defend oneself. However, what are these advice based on? And more importantly, is the quality of the advice in line with the best practices or are they misleading? The goal of this topic is to design an expert study where various advice given by ChatGPT on security topics (e.g., password policies, phishing, etc.) are compared against the advice of experts. The results then need to be analysed and classified to determine the quality of ChatGPT advice.

Run Usable Security Studies and Results Analysis
These topics are related to run and analyse the results of user-studies. Online studies, interviews and lab studies are all possible, depending on the topic. At the end of the semester, the students present a report / paper with the analyses conducted and a talk in which they present the results.
Title: Phishing through homographic attacks in messengers and social networks
Number of students: 1-2 Bachelor or Master level
Description: The task will be to test three types of attacks in messengers and social networks that work in some email clients. First is the link mismatch attack, where the link text differs from the actual link target. Second is an attack in which the actual link target is disguised by URL encoding [https://en.wikipedia.org/wiki/URL_encoding], and finally homographic attacks which uses Internationalized Domain Names [https://en.wikipedia.org/wiki/IDN_homograph_attack], in which Latin characters are replaced by characters of a different alphabet in the domain name. The attacks are predefined, so no knowledge of phishing techniques is required.

Title: Usability Study of Mobile Authentication for Elderly Users with Rheumatoid Arthritis (English only)
Number of students: 1 Bachelor or Master level
Description: Authentication is an ever important topic, especially in the mobile context. However, it becomes even more relevant when considering accessibility to it. Nowadays, a common authentication method is using a PIN. Yet, given the low hand mobility of users affected by rheumatoid arthritis, sometimes using PINs can be difficult. In this topic, the student will conduct several sessions of an already designed lab study with various participants using arthritis simulation gloves to evaluate three PIN-pad interfaces aimed at making authentication more accessible. The study will also investigate the preferences of users regarding PIN-pad interfaces through drawings and proposals of changes. The student will then analyse the results through inferential statistics. Depending on the quality of the outcome, the results will then be published in a paper and the student will be added to the authors list.

This event counts towards the KASTEL certificate. Further information on how to obtain the certificate can be found on the SECUSO website (https://secuso.aifb.kit.edu/Studium_und_Lehre.php).

Praktikum Security, Usability and Society (Master)
2512555, WS 24/25, 3 SWS, Language: German/English, Open in study portal
Content
The Praktikum Security, Usability and Society will cover topics both of usable security and privacy programming, and how to conduct user studies. To reserve a place, please, register on the WiWi portal and send an email with your chosen topic, plus a back-up one, to mattia.mossano@kit.edu. Topics are assigned first-come-first-served until all of them are filled. Topics in italics have been already assigned.

There are two deadlines:

Important dates:
Kick-off: 05.10.2023, 09:00 AM CET in Big Blue Button - Link
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Topics:

Programming Usable Security Intervention
In this subject, students develop a part of coding, an extension, or another programming task dealing with various usable security interventions, eg as an extension. Eg TORPEDO (https://secuso.aifb.kit.edu/english/TORPEDO.php) or PassSec + (https://secuso.aifb.kit.edu/english/PassSecPlus.php). Just as before, students are provided with a point list of goals, containing both basic features mandatory to pass the course and more advanced ones that heighten the final grade.

Title: Making e-mails more visible by embedding moving images
Number of students: 1 Master
Description: In case of a security incident, it is necessary to inform the affected persons about their vulnerabilities as soon as possible. Within the context of the INSPECTION project, we are currently informing website owners via e-mail about security related vulnerabilities on their websites. Although e-mails have been shown to be the most cost-efficient means to deliver such information, they have not lead to an appropriate remediation rate. While speaking to the affected website owners we learned that they would appreciate more information, although not being delivered as more text in the e-mail. Also, we learned that most e-mails were not read because they were considered spam. Thus, we need to find a way to make e-mail notifications more effective in raising peoples’ awareness. Videos have been proven effective to raise awareness in the context of IT security. The goal of the project will be, to explore ways to embed videos in an e-mail via HTML (either as gifs or as preview to a YouTube video). The challenge is to make this e-mail readable for different clients and webmail as well as getting it delivered through spam filters.

Designing Security User studies
These topics are related to how to set up and conduct user studies of various types. Online studies, interviews and lab studies are possible. At the end of the semester, the students present a report / paper and a talk in which they present their methodologies and the results of small pre-studies.

Title: Designing User Studies for Evaluating Biometric Authentication Systems
Number of students: 1 Bachelor or Master level
Description: The proposed topic focuses on designing and implementing a user study methodology to evaluate the usability and user perception of biometric authentication systems. Biometric authentication involves using unique physiological or behavioral characteristics, such as fingerprints, facial recognition, or voice patterns, to verify a user's identity. The goal of this research is to understand the factors that affect the effectiveness and acceptance of biometric authentication and provide insights for designing user-friendly and secure biometric authentication systems.

Title: Can anxiety influences security advice?
Number of students: 1 Master level
Description: Nowadays ChatGPT is used for a multitude of reasons. One is to ask advice on security topics. However, previous research showed that oftentimes ChatGPT creates answers based on previous interactions with it. Therefore, is it possible that also security advice change according to the previous interaction? And if this is the case, can more anxious props lead to completely different results? The student will have to read the previous literature on ChatGPT, find expert advice on security topics and create an experiment to determine if anxiety influenced the advice given by ChatGPT.
Title: Investigating ChatGPT privacy tradeoffs and users perception of them (English only)
Number of students: 1 Master level
Description: As ChatGPT grows in popularity, it becomes increasingly vital to examine the privacy trade-offs associated with its usage. The user's willingness to accept these trade-offs is instrumental in understanding the wider implications of employing AI language models. This topic involves a two-part exploration into the privacy trade-offs of using ChatGPT. Initially, the student will analyse ChatGPT's Terms and Conditions and conduct a short literature review to identify potential privacy trade-offs. The found trade-offs need to be categorised into a set of trade-offs that will be investigated. Subsequently, the student will design an online user study, incorporating various question types and a deception study, to gauge the willingness of ChatGPT users to accept these trade-offs. Finally, the student will test the designed online user study in the course of small pre-test.

Run Usable Security Studies and Results Analysis
These topics are related to run and analyse the results of user-studies. Online studies, interviews and lab studies are all possible, depending on the topic. At the end of the semester, the students present a report / paper with the analyses conducted and a talk in which they present the results.
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This event counts towards the KASTEL certificate. Further information on how to obtain the certificate can be found on the SECUSO website (https://secuso.aifb.kit.edu/Studium_und_Lehre.php).
# Course: Advanced Lab Sociotechnical Information Systems Development (Master) [T-WIWI-111125]

**Responsible:** Prof. Dr. Ali Sunyaev  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics

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*Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled*

**Competence Certificate**

The alternative exam assessment consists of:

- a practical work
- a presentation and
- a written seminar thesis

Practical work, presentation and written thesis are weighted according to the course.

**Prerequisites**

None

**Responsible:** Dr. Björn de Rijk  
Prof. Dr. Wolfgang Reichel

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-106822 - Advanced Methods in Nonlinear Partial Differential Equations

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**Competence Certificate**

The module examination takes place in form of an oral exam of about 30 minutes.

**Prerequisites**

none

**Recommendation**

The following modules are recommended: Analysis 1-3, Functional Analysis, Evolution Equations.
**4.13 Course: Advanced Stochastic Optimization [T-WIWI-106548]**

**Responsible:** Prof. Dr. Steffen Rebennack  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101473 - Mathematical Programming

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**Exams**

| ST 2024 | 7900034 | Advanced Stochastic Optimization | Rebennack |

**Competence Certificate**
The assessment consists of an oral exam (20 minutes). The exam is offered every semester.

**Prerequisites**
None.

**Annotation**
Lectures and tutorials are offered irregularly.
4.14 Course: Advanced Topics in Economic Theory [T-WIWI-102609]

**Responsible:** Prof. Dr. Kay Mitusch  
**Organisation:** KIT Department of Economics and Management  
**Part of:**  
- M-WIWI-101500 - Microeconomic Theory  
- M-WIWI-101502 - Economic Theory and its Application in Finance

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**Exams**

| ST 2024 | 7900329 | Advanced Topics in Economic Theory | Mitusch, Brumm |

**Legend:**  
- 🖥 Online  
- 🧩 Blended (On-Site/Online)  
- 🗣 On-Site  
- ✗ Cancelled

**Competence Certificate**

The assessment consists of a written exam (60 min) (following §4(2), 1 of the examination regulation) at the end of the lecture period or at the beginning of the following semester.

**Prerequisites**

None

**Recommendation**

This course is designed for advanced Master students with a strong interest in economic theory and mathematical models. Bachelor students who would like to participate are free to do so, but should be aware that the level is much more advanced than in other courses of their curriculum.

*Below you will find excerpts from events related to this course:*

**Advanced Topics in Economic Theory**  
2520527, SS 2024, 2 SWS, Language: English, [Open in study portal](#)

**Literature**

Die Veranstaltung wird in englischer Sprache angeboten:

The course is based on the excellent textbook "Microeconomic Theory" (Chapters 1-5, 10, 13-20) by A. Mas-Colell, M.D. Whinston, and J.R. Green.
### 4.15 Course: Algebra [T-MATH-102253]

**Responsible:** PD Dr. Stefan Kühnlein  
Prof. Dr. Roman Sauer  

**Organisation:** KIT Department of Mathematics  

Part of: **M-MATH-101315 - Algebra**

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Legend: 🖥 Online, 🎭 Blended (On-Site/Online), 🗣️ On-Site, ✗ Cancelled
## 4.16 Course: Algebraic Geometry [T-MATH-103340]

** Responsible:** Prof. Dr. Frank Herrlich  
PD Dr. Stefan Kühnlein  
** Organisation:** KIT Department of Mathematics  
** Part of:** M-MATH-101724 - Algebraic Geometry

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</table>

4.17 Course: Algebraic Number Theory [T-MATH-103346]

**Responsible:** Prof. Dr. Frank Herrlich  
PD Dr. Stefan Kühnlein

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-101725 - Algebraic Number Theory

<table>
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<tr>
<td>Oral examination</td>
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<td>Grade to a third</td>
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**Competence Certificate**
oral examination of ca. 30 minutes

**Prerequisites**
none
### 4.18 Course: Algebraic Topology [T-MATH-105915]

**Responsible:** TT-Prof. Dr. Manuel Krannich  
Prof. Dr. Roman Sauer  

**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102948 - Algebraic Topology

**Type:** Written examination  
**Credits:** 8  
**Grading scale:** Grade to a third  
**Recurrence:** Irregular  
**Version:** 1

**Prerequisites:** none
### 4.19 Course: Algebraic Topology II [T-MATH-105926]

**Responsible:** Prof. Dr. Roman Sauer  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102953 - Algebraic Topology II

<table>
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**Prerequisites**  
none
4.20 Course: Algorithm Engineering [T-INFO-101332]

**Responsible:** Prof. Dr. Peter Sanders

**Organisation:** KIT Department of Informatics

**Part of:** M-INFO-100795 - Algorithm Engineering

<table>
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<td>Each summer term</td>
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**Competence Certificate**

There are two partial achievements Algorithm Engineering (4 ECTS) and Algorithm Engineering Exercises (1 ECTS):

Algorithm Engineering:

The assessment is carried out as an oral examination lasting 20 minutes. § 4 Abs. 2 Nr. 2 SPO

Algorithm Engineering Exercises:

The assessment is carried out as an examination of another type.

The exercise can be evidenced by various performance records. This is determined individually during the lecture. Usually, the student prepares a seminar presentation and/or works on a practical tasks with written elaboration and evaluation (the main performance consists of the programming, documented by the source code that is to be handed in and supplemented by a short written report). Students may redraw from the examination during the first XXX??? weeks after they have been assigned a task.

**Prerequisites**

none.

**Modeled Conditions**

The following conditions have to be fulfilled:

1. The course T-INFO-111856 - Algorithm Engineering Pass must have been started.
### 4.21 Course: Algorithm Engineering Pass [T-INFO-111856]

**Responsible:** Prof. Dr. Peter Sanders  
**Organisation:** KIT Department of Informatics  
**Part of:** M-INFO-100795 - Algorithm Engineering

<table>
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<td>Each summer term</td>
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**Competence Certificate**  
There are two partial achievements Algorithm Engineering (4 ECTS) and Algorithm Engineering Exercises (1 ECTS):  
Algorithm Engineering:  
The assessment is carried out as an oral examination lasting 20 minutes.

**Algorithm Engineering Exercises:**  
The assessment is carried out as an examination of another type. § 2 Abs. 2 Nr. 3  
The exercise can be evidenced by various performance records. This is determined individually during the lecture. Usually, the student prepares a seminar presentation and/or works on a practical tasks with written elaboration and evaluation (the main performance consists of the programming, documented by the source code that is to be handed in and supplemented by a short written report). Students may redraw from the examination during the first XXX?? weeks after they have been assigned a task.

**Prerequisites**  
none.
4.22 Course: Analytical and Numerical Homogenization [T-MATH-111272]

**Responsible:** Prof. Dr. Marlis Hochbruck
TT-Prof. Dr. Roland Maier

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105636 - Analytical and Numerical Homogenization

<table>
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**Prerequisites**
none
4.23 Course: Applications of Topological Data Analysis [T-MATH-111290]

**Responsible:** Dr. Andreas Ott

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105651 - Applications of Topological Data Analysis

<table>
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**Prerequisites**
none

**Responsible:** Prof. Dr. Ali Sunyaev
**Organisation:** KIT Department of Economics and Management
**Part of:** M-WIWI-101472 - Informatics

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**Events**

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<th>Instructor</th>
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<td>ST 2024</td>
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<td>Applied Informatics - Internet Computing</td>
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<td>Lecture / 🗣</td>
<td>Sunyaev</td>
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<td>2511033</td>
<td>Übungen zu Angewandte Informatik - Internet Computing</td>
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<td>Practice /🧩</td>
<td>Sunyaev, Rank, Guse</td>
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**Exams**

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<th>Title</th>
<th>SWS</th>
<th>Type</th>
<th>Duration</th>
<th>Instructor</th>
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<td>Applied Informatics - Internet Computing (Registration until 15 July 2024)</td>
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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, X Cancelled

**Competence Certificate**
The assessment consists of a written exam (60 min) according to Section 4(2), 1 of the examination regulation. The successful completion of the exercises is recommended for the written exam, which is offered at the end of the winter semester and at the end of the summer semester.

Successful participation in the exercise by submitting correct solutions to 50% of the exercises can earn a grade bonus. If the grade of the written exam is at least 4.0 and at most 1.3, the bonus will improve it by one grade level (i.e. by 0.3 or 0.4).

**Prerequisites**
None

Below you will find excerpts from events related to this course:

**V Applied Informatics - Internet Computing**

2511032, SS 2024, 2 SWS, Language: German, [Open in study portal]

**Content**
The lecture Applied Computer Science - Internet Computing provides insights into fundamental concepts and future technologies of distributed systems and Internet computing. Students should be able to select, design and apply the presented concepts and technologies. The course first introduces basic concepts of distributed systems (e.g. design of architectures for distributed systems, Internet architectures, web services, middleware).

In the second part of the course, emerging technologies of Internet computing will be examined in depth. These include, among others:

- Cloud Computing
- Edge & Fog Computing
- Internet of Things
- Blockchain
- Artificial Intelligence

**Learning objectives:**
The student learns about basic concepts and emerging technologies of distributed systems and Internet computing. Practical topics will be deepened in lab classes.

**Recommendations:**
Knowledge of content of the module [WI1INFO].

**Workload:**
The total workload for this course is approximately 135-150 hours.
Literatur
Wird in der Vorlesung bekannt gegeben
Course: Applied Information Theory [T-ETIT-100748]

<table>
<thead>
<tr>
<th>Responsible:</th>
<th>Dr.-Ing. Holger Jäkel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation:</td>
<td>KIT Department of Electrical Engineering and Information Technology</td>
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<td>Part of:</td>
<td>M-ETIT-100444 - Applied Information Theory</td>
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<tbody>
<tr>
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<td>6</td>
<td>Grade to a third</td>
<td>Each winter term</td>
<td>1</td>
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</table>

| Exams       | ST 2024 | 7310537-1 | Applied Information Theory | Jäkel |

**Competence Certificate**
The success control takes place in the form of an oral examination lasting 25 minutes. Before the examination, there is a preparation phase of 15 minutes in which preparatory tasks are solved.

**Prerequisites**
none
4.26 Course: Applied material flow simulation [T-MACH-112213]

**Responsible:** Dr.-Ing. Marion Baumann  
**Organisation:** KIT Department of Mechanical Engineering  
**Part of:** M-WIWI-102832 - Operations Research in Supply Chain Management

<table>
<thead>
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<tbody>
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<td>4,5</td>
<td>Grade to a third</td>
<td>Each winter term</td>
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**Events**

<table>
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<tr>
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<th>Recurrence</th>
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<td>WT 24/25 2117054</td>
<td>Applied material flow simulation</td>
<td>3 SWS</td>
<td>Lecture / Practice</td>
<td>Baumann</td>
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</tr>
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</table>

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗼 On-Site, 🗿 Cancelled

**Competence Certificate**

The assessment consists of an oral exam (20 min.) taking place in the recess period according to § 4 paragraph 2 Nr. 2 of the examination regulation.

**Prerequisites**

None

**Recommendation**

- Basic statistical knowledge and understanding
- Knowledge of a common programming language (Java, Python, ...)
- Recommended course: T-WIWI-102718 - Discrete Event Simulation in Production and Logistics

**Below you will find excerpts from events related to this course:**

**Applied material flow simulation**

2117054, WS 24/25, 3 SWS, Language: German, Open in study portal  
Lecture / Practice (VÜ)  
On-Site
Content

Learning Content:

- Methods of modeling a simulation such as:
  - Discrete-event simulation
  - Agent based simulation
- Design of a simulation model of a material flow system
- Data exchange in simulation models
- Verification and validation of simulation models
- Execution of simulation studies
- Statistical evaluation and parameter study

This is an application-oriented course in which the course contents are applied and deepened using the Anylogic software.

Learning Goals:

Students are able to:

- select the appropriate simulation modeling method depending on a modeling objective and build a suitable simulation model for material flow systems,
- extend a simulation model in a meaningful way with data import and export,
- verify and validate a simulation model,
- conduct a simulation study efficiently and with meaningful results, and
- design and conduct a parameter study and statistically analyze and evaluate the results.

Recommendations:

- Basic statistical skills
- Prior knowledge of a common programming language (Java, Python, ...).
- Recommended course: T-WIWI-102718 - Discrete Event Simulation in Production and Logistics

Workload for 4,5 ECTS (135 h):

- regular attendance: 21 hours
- self-study: 114 hours

Organizational issues

- Im Wintersemester 2024/2025 ist die Veranstaltung auf maximal 30 Teilnehmer beschränkt.
- Die Anmeldung ist durch Beitritt zum ILIAS-Kurs und Ausfüllen des Anmeldungsformulars (erforderliche Felder beim Beitritt zum ILIAS-Kurs) möglich.
- Die Anmeldung ist vom 01.09.2024 bis zum 30.09.2024 möglich.

Literature


4.27 Course: Aspects of Geometric Analysis [T-MATH-106461]

**Responsibility:** Prof. Dr. Tobias Lamm

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-103251 - Aspects of Geometric Analysis

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<td>4</td>
<td>Grade to a third</td>
<td>Irregular</td>
<td>1</td>
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**Events**

| ST 2024 | 0176600 | AG Geometrische Analysis | 2 SWS | Seminar | Lamm |

**Prerequisites**

Keine
### 4.28 Course: Asset Pricing [T-WIWI-102647]

**Responsible:** Prof. Dr. Martin Ruckes  
Prof. Dr. Marliese Uhrig-Homburg  

**Organisation:**  
KIT Department of Economics and Management  

**Part of:**  
M-WIWI-101480 - Finance 3  
M-WIWI-101482 - Finance 1  
M-WIWI-101483 - Finance 2  
M-WIWI-101502 - Economic Theory and its Application in Finance

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<td>Grade to a third</td>
<td>Each summer term</td>
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**Events**

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<th>Credits</th>
<th>Grading</th>
<th>Teacher(s)</th>
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<td>2 SWS</td>
<td>Lecture / On-Site</td>
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<td>ST 2024</td>
<td>2530556</td>
<td>Asset Pricing</td>
<td>1 SWS</td>
<td>Practice / On-Site</td>
<td>Böll, Uhrig-Homburg, Müller</td>
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**Exams**

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<th>Semester</th>
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<th>Type</th>
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<td>Asset Pricing</td>
<td>Uhrig-Homburg, Thimme</td>
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<td>WT 24/25</td>
<td>7900056</td>
<td>Asset Pricing</td>
<td>Uhrig-Homburg</td>
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**Legend:**  
🖥 Online, 🧩 Blended (On-Site/Online), On-Site, ❌ Cancelled

**Competence Certificate**

Depending on further pandemic developments, the examination will be offered either as a 60-minute written examination or as an open-book examination (alternative exam assessment).

A bonus can be earned by correctly solving at least 50% of the posed bonus exercises. If the grade of the written examination is between 4.0 and 1.3, the bonus improves the grade by up to one grade level (0.3 or 0.4). Details will be announced in the lecture.

**Prerequisites**

None

**Recommendation**

We strongly recommend knowledge of the basic topics in investments (bachelor course), which will be necessary to be able to follow the course.

---

**Below you will find excerpts from events related to this course:**

### Asset Pricing

2530556, SS 2024, 1 SWS, Language: German, [Open in study portal](#)

**Practice (Ü)**  
On-Site
## 4.29 Course: Asymmetric Encryption Schemes [T-INFO-101260]

**Responsible:** Prof. Dr. Jörn Müller-Quade  
**Organisation:** KIT Department of Informatics  
**Part of:** M-INFO-100723 - Asymmetric Encryption Schemes

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<td>Grade to a third</td>
<td>Each winter term</td>
<td>1</td>
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</table>
### Course: Auction Theory [T-WIWI-102613]

#### Responsible:
Prof. Dr. Karl-Martin Ehrhart

#### Organisation:
KIT Department of Economics and Management

#### Part of:
- M-WIWI-101500 - Microeconomic Theory
- M-WIWI-102970 - Decision and Game Theory

**Type**
- Written examination

**Credits**
- 4,5

**Grading scale**
- Grade to a third

**Recurrence**
- Each winter term

**Version**
- 1

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#### Events

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<td>Auction Theory</td>
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<td>WT 24/25</td>
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<td>Auction Theory Exercise</td>
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<th>Type</th>
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<td>2 SWS</td>
<td>Auction Theory</td>
<td>Ehrhart</td>
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**Competence Certificate**

The assessment of this course is a written examination (following §4(2), 1 SPO) of 60 mins. The exam is offered each semester.

**Prerequisites**

None

---

**Below you will find excerpts from events related to this course:**

**V Auction Theory**

2520408, WS 24/25, 2 SWS, Open in study portal

Lecture (V)

---

**Literature**

- Ehrhart, K.-M. und S. Seifert: Auktionstheorie, Skript zur Vorlesung, KIT, 2011
- Ausubel, L.M. und P. Cramton: Demand Reduction and Inefficiency in Multi-Unit Auctions, University of Maryland, 1999
4.31 Course: Banach Algebras [T-MATH-105886]

**Responsible:** PD Dr. Gerd Herzog  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102913 - Banach Algebras

**Type**  
Oral examination

**Credits**  
3

**Grading scale**  
Grade to a third

**Version**  
1

**Prerequisites**

none
4.32 Course: Basics Module - Self Assignment BAK [T-ZAK-112653]

**Responsible:** Dr. Christine Mielke
Christine Myglas

**Organisation:**
Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

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<th>Version</th>
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<tbody>
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<td>pass/fail</td>
<td>1</td>
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</table>

**Competence Certificate**
The monitoring in this module includes a course credit according to § 5 section 4 in the form of minutes of which two are to be handed in freely chosen topics of the lecture series "Introduction to Applied Studies on Culture and Society". Length: approx. 6,000 characters each (incl. spaces).

**Self service assignment of supplementary studies**
This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

**Recommendation**

**Annotation**
The Basic Module consists of the lecture "Introduction to Supplementary Studies on Culture and Society", which is offered only in the winter semester. It is therefore recommended that students start their studies in the winter semester and complete them before module 2.
4.33 Course: Basics Module - Self Assignment BeNe [T-ZAK-112345]

**Responsible:** Christine Myglas

**Organisation:**

Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

<table>
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<th>Credits</th>
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<tbody>
<tr>
<td>Completed coursework</td>
<td>3</td>
<td>pass/fail</td>
<td>1</td>
</tr>
</tbody>
</table>

**Competence Certificate**
The monitoring in this module includes a course credit according to § 5 section 4:

*Introduction to Sustainable Development* in the form of minutes of which two are to be handed in freely chosen topics of the lecture series "Introduction to Sustainable Development". Length: approx. 6,000 characters each (incl. spaces).

or

*Sustainability Spring Days at KIT* in the form of a reflection report on all components of the project days "Sustainability Spring Days at KIT". Length approx. 12,000 characters (incl. spaces).

**Prerequisites**

None

**Self service assignment of supplementary studies**
This course can be used for self service assignment of grade acquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

**Recommendation**

**Annotation**
Module Basics consists of the lecture "Introduction to Sustainable Development", which is only offered in the summer semester or alternatively of the project days "Sustainability Spring Days at KIT", which is only offered in the winter semester. It is recommended to complete the course before Elective Module or Specialisation Module.

In exceptional cases, Elective Module or Specialisation Module can also be completed simultaneously with Basics Module. However, the prior completion of the advanced modules Elective and Specialisation should be avoided.
### 4.34 Course: Batteries and Fuel Cells [T-ETIT-100983]

**Responsible:** Prof. Dr.-Ing. Ulrike Krewer  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100532 - Batteries and Fuel Cells

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#### Events

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<td>Krewer</td>
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<td>Practice / 🗤</td>
<td>1 SWS</td>
<td>Grade to a third</td>
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<td>Batteries and Fuel Cells (Exercise to 2304207)</td>
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#### Exams

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**Legend:** 🛜 Online, 🛜 Blended (On-Site/Online), 🗤 On-Site, ✖ Cancelled

**Prerequisites**

none

**Below you will find excerpts from events related to this course:**

#### Batteries and Fuel Cells  
**2304207, WS 24/25, 2 SWS, Language: German, [Open in study portal](#)**  
**Lecture (V) Blended (On-Site/Online)**

**Content**

The lecture provides a practical insight into the current application areas and research topics of fuel cells and batteries. It deals with the design and functionality of electrochemical energy conversion and storage devices and provides knowledge about materials, cell designs, measurement methods, data analysis and modelling. The lecture and most slides are in German.

**Organizational issues**

Veranstaltungstermine: 28.10.2024 - 10.02.2025

ILIAS Kurs
4.35 Course: Bayesian Inverse Problems with Connections to Machine Learning [T-MATH-112842]

**Responsible:** TT-Prof. Dr. Sebastian Krumscheid

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-106328 - Bayesian Inverse Problems with Connections to Machine Learning

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**Exams**

| ST 2024 | 7700131 | Bayesian Inverse Problems with Connections to Machine Learning | Krumscheid |

**Competence Certificate**
oral exam of ca. 30 min

**Prerequisites**
none
**4.36 Course: Bifurcation Theory [T-MATH-106487]**

<table>
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<tr>
<th>Responsible</th>
<th>Dr. Rainer Mandel</th>
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<td>Version</td>
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**Prerequisites**
None
4.37 Course: Bond Markets [T-WIWI-110995]

**Responsible:** Prof. Dr. Marliese Uhrig-Homburg

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101480 - Finance 3
- M-WIWI-101483 - Finance 2

<table>
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**Exams**

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<td>Bond Markets</td>
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Legend: 🖥 Online, 📚 Blended (On-Site/Online), ☀ On-Site, ✗ Cancelled

**Competence Certificate**

The assessment consists of a written exam (75min.)

A bonus can be earned by correctly solving at least 50% of the posed bonus exercises. If the grade of the written examination is between 4.0 and 1.3, the bonus improves the grade by up to one level (0.3 or 0.4). The examination is offered in each semester and can be repeated at any regular examination date.

Depending on further pandemic developments, the examination will be offered as an open-book examination (alternative exam assessment).

**Annotation**

This course will be held in English.

*Below you will find excerpts from events related to this course:*

**Bond Markets**

2530560, WS 24/25, 3 SWS, Language: English, [Open in study portal]

**Content**

The lecture "Bond Markets" deals with the national and international bond markets, which are an important source of financing for companies, as well as for the public sector. After an overview of the most important bond markets, different yield definitions are discussed. Based on this, the concept of the yield curve is presented. In addition, the theoretical and empirical relationships between ratings, default probabilities and spreads are analyzed. The focus will then be on questions regarding the valuation, measurement, management and control of credit risks.

The total workload for this course is approximately 135 hours (4.5 credits).

The assessment consists of a written exam (75min.) (according to §4(2), 1 SPO). A bonus can be earned by correctly solving at least 50% of the posed bonus exercises. If the grade of the written examination is between 4.0 and 1.3, the bonus improves the grade by up to one level (0.3 or 0.4). The examination is offered in each semester and can be repeated at any regular examination date.

Students deepen their knowledge of national and international bond markets. They gain knowledge of the traded instruments and their key figures for describing default risk such as ratings, default probabilities or credit spreads.

**Organizational issues**

Die Veranstaltung wird in der ersten Semesterhälfte an sechs Freitagen am Campus B (Geb. 09.21) im Raum 124 angeboten. Die Klausur findet dann direkt im Anschluss statt.
Course: Bond Markets - Models & Derivatives [T-WIWI-110997]

**Responsibility:** Prof. Dr. Marliese Uhrig-Homburg

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101480 - Finance 3
- M-WIWI-101483 - Finance 2

**Type:** Examination of another type

**Credits:** 3

**Grading scale:** Grade to a third

**Recurrence:** Each winter term

**Version:** 1

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<td>2 SWS</td>
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<td>Bond Markets - Models &amp; Derivatives</td>
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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**
The assessment of success consists in equal parts of a written thesis and an oral exam including a discussion of one's own work. The main examination is offered once a year, re-examinations every semester.

**Recommendation**
Knowledge of "Bond Markets" and "Derivatives" courses is very helpful.

**Annotation**
This course will be held in English.

**Below you will find excerpts from events related to this course:**

**Bond Markets - Models & Derivatives**

2530565, WS 24/25, 2 SWS, Language: English, [Open in study portal](#)

**Content**

- **Competence Certificate:** The assessment of success consists in equal parts of a written thesis and an oral exam (according to §4(2), 3 SPO) including a discussion of one's own work. The main examination is offered once a year, re-examinations every semester.
- **Competence Goal:** Students deepen their knowledge of national and international bond markets. They are able to apply the knowledge they have gained about traded instruments and common valuation models for pricing derivative financial instruments.
- **Prerequisites:**
- **Content:** The lecture "Bond Markets – Models & Derivatives" deepens the content of the lecture "Bond Markets". The modelling of the dynamics of yield curves and the management of credit risks forms the theoretical foundation for the valuation of interest rate and credit derivatives to be discussed. In this course, students deal intensively with selected topics and acquire the relevant knowledge on their own.
- **Recommendation:** Knowledge of "Bond Markets" and "Derivatives" courses is very helpful.
- **Workload:** The total workload for this course is approximately 90 hours (3.0 credits).

**Organizational issues**

Die Veranstaltung startet in der zweiten Semesterhälfte und hat Seminarcharakter - mit dem Ziel, ein selbstgewähltes Themenfeld in Form einer schriftlichen Ausarbeitung eigenständig zu erarbeiten.
4.39 Course: Bond Markets - Tools & Applications [T-WIWI-110996]

Responsible: Prof. Dr. Marliese Uhrig-Homburg
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101480 - Finance 3
M-WIWI-101483 - Finance 2

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Events

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<td>1 SWS</td>
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<td>Uhrig-Homburg, Grauer</td>
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Exams

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<td>Uhrig-Homburg</td>
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Legend: 🖥 Online,🧩 Blended (On-Site/Online),🗣 On-Site,❌ Cancelled

Competence Certificate
The assessment consists of an empirical case study with written elaboration and presentation. The main examination is offered once a year, re-examinations every semester.

Recommendation
Knowledge of the "Bond Markets" course is very helpful.

Annotation
This course will be held in English.

Below you will find excerpts from events related to this course:

Bond Markets - Tools & Applications
2530562, WS 24/25, 1 SWS, Language: English, Open in study portal

Content

- **Competence Certificate:** The assessment consists of an empirical case study with written elaboration and presentation (according to §4(2), 3 SPO). The main examination is offered once a year, re-examinations every semester.
- **Competence Goal:** The students apply various methods in practice within the framework of a project-related case study. They are able to deal with empirical data and analyze them in a targeted manner.
- **Content:** The course “Bond Markets – Tools & Applications” includes a hands-on project in the field of national and international bond markets. Using empirical datasets, the students have to apply practical methods in order to analyze the data in a targeted manner.
- **Recommendation:** Knowledge of the "Bond Markets" course is very helpful.
- **Workload:** The total workload for this course is approximately 45 hours (1.5 credits).

Organizational issues
4.40 Course: Bott Periodicity [T-MATH-108905]

**Responsible:** Prof. Dr. Wilderich Tuschmann

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-104349 - Bott Periodicity

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**Prerequisites**
none
Below you will find excerpts from events related to this course:

**Boundary and Eigenvalue Problems**
0157500, SS 2024, 4 SWS, Open in study portal

**Lecture (V)**

**Content**
We consider boundary value and eigenvalue problems within mathematics and physics, describe qualitative properties of solutions, prove the existence of solutions to boundary value problems using functional analytical methods and will work in more general function spaces, e.g. Sobolev spaces. Further contents are the weak formulation of 2nd order linear elliptic equations, existence and regularity theory of elliptic equations, as well as, eigenvalue theory for weakly formulated elliptic eigenvalue problems.
4.42 Course: Boundary Element Methods [T-MATH-109851]

**Responsible:** PD Dr. Tilo Arens  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-103540 - Boundary Element Methods

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**Prerequisites**

none
4.43 Course: Boundary Value Problems for Nonlinear Differential Equations [T-MATH-105847]

**Responsible:** Prof. Dr. Michael Plum
Prof. Dr. Wolfgang Reichel

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102876 - Boundary value problems for nonlinear differential equations

**Type**
Oral examination

**Credits**
8

**Grading scale**
Grade to a third

**Version**
1
4.44 Course: Brownian Motion [T-MATH-105868]

Responsibilities:
Prof. Dr. Nicole Bäuerle
Prof. Dr. Vicky Fasen-Hartmann
Prof. Dr. Günter Last

Organisation:
KIT Department of Mathematics

Part of:
M-MATH-102904 - Brownian Motion

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Prerequisites:
none
### Course: Business Process Modelling [T-WIWI-102697]

**Responsible:** Prof. Dr. Andreas Oberweis  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics

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#### Events

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<td>Lecture / On-Site</td>
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#### Exams

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), ☞ On-Site, ✗ Cancelled

#### Competence Certificate

The assessment of this course is a written examination (60 min) according to §4(2), 1 of the examination regulation in the first week after lecture period.

#### Prerequisites

None

#### Below you will find excerpts from events related to this course:

**Business Process Modelling**  
2511210, WS 24/25, 2 SWS, Language: German, [Open in study portal](#)

**Lecture (V)**  
On-Site

#### Content

The proper modeling of relevant aspects of business processes is essential for an efficient and effective design and implementation of processes. This lecture presents different classes of modeling languages and discusses the respective advantages and disadvantages of using actual application scenarios. For that simulative and analytical methods for process analysis are introduced. In the accompanying exercise the use of process modeling tools is practiced.

#### Learning objectives:

Students

- describe goals of business process modeling and apply different modeling languages,
- choose the appropriate modeling language according to a given context,
- use suitable tools for modeling business processes,
- apply methods for analysing and assessing process models to evaluate specific quality characteristics of the process model.

#### Recommendations:

Knowledge of course Applied Informatics I - Modelling is expected.

#### Workload:

- Lecture 30h
- Exercise 15h
- Preparation of lecture 24h
- Preparation of exercises 25h
- Exam preparation 40h
- Exam 1h
**Literature**


Weitere Literatur wird in der Vorlesung bekannt gegeben.
### 4.46 Course: Business Strategies of Banks [T-WIWI-102626]

| **Responsible:** | Prof. Dr. Wolfgang Müller |
| **Organisation:** | KIT Department of Economics and Management |
| **Part of:** | M-WIWI-101480 - Finance 3  
M-WIWI-101483 - Finance 2 |

| **Type** | Written examination |
| **Credits** | 3 |
| **Grading scale** | Grade to a third |
| **Recurrence** | see Annotations |
| **Version** | 1 |

**Competence Certificate**
The lecture will be offered for the last time in the winter semester 2021/22. The exam will take place for the last time in the summer semester 2022 (only for repeaters).

**Prerequisites**
None

**Recommendation**
None

**Annotation**
The lecture will be offered for the last time in the winter semester 2021/22.
## 4.47 Course: Classical Methods for Partial Differential Equations [T-MATH-105832]

**Responsible:** Prof. Dr. Dorothee Frey  
Prof. Dr. Dirk Hundertmark  
Prof. Dr. Tobias Lamm  
Prof. Dr. Michael Plum  
Prof. Dr. Wolfgang Reichel  
Prof. Dr. Roland Schnaubelt

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102870 - Classical Methods for Partial Differential Equations

### Type
<table>
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### Credits
| 8 |

### Grading scale
| Grade to a third |

### Version
| 1 |

### Events

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<th>Classical Methods for Partial Differential Equations</th>
<th>4 SWS</th>
<th>Lecture</th>
<th>Zillinger</th>
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<td>Tutorial for 0105300 (Classical Methods for Partial Differential Equations)</td>
<td>2 SWS</td>
<td>Practice</td>
<td>Zillinger</td>
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### Exams

| ST 2024 | 7700052 | Classical Methods for Partial Differential Equations | Reichel, Anapolitanos, Liao, Hundertmark, Lewintan |
4.48 Course: Coding Theory [T-INFO-113693]

**Responsible:** Prof. Dr. Jörn Müller-Quade

**Organisation:** KIT Department of Informatics

**Part of:** M-INFO-106824 - Coding Theory

<table>
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<tbody>
<tr>
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</table>

**Competence Certificate**
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 120 minutes. Depending on the number of participants, it will be announced six weeks before the examination (Section 6 (3) SPO) whether the assessment will take the form of an oral examination of approx.

- in the form of an oral examination of approx. 30 minutes in accordance with § 4 Para. 2 No. 2 SPO or
- in the form of a written examination in accordance with § 4 Para. 2 No. 1 SPO
  takes place.

**Prerequisites**
None.

**Modeled Conditions**
The following conditions have to be fulfilled:

1. The course T-INFO-101360 - Signals and Codes must not have been started.

**Recommendation**
None.

Below you will find excerpts from events related to this course:

**Coding Theory**
2400152, WS 24/25, 2 SWS, Language: German, [Open in study portal]

**Content**
This lecture mainly deals with channel coding. It examines how signals can be protected against random noise affecting the transmission channel. Bounds of codes (Hamming, Gilbert-Varshamov, Singleton) are presented. In addition to the coding and decoding of classical algebraic codes (linear, Reed Solomon, Goppa and Reed Muller codes), concatenated codes and sums of codes are also covered. In addition, a connection to cryptography, in particular the McEliece encryption method, is established.
4.49 Course: Collective Perception in Autonomous Driving [T-WIWI-113363]

**Responsible:** Prof. Dr. Alexey Vinel

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101472 - Informatics

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**Events**

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🔹 On-Site, ☑ Cancelled

**Competence Certificate**

The default assessment of this course is a written examination (60 min).

The exam takes place every semester and can be repeated at every regular examination date.

**Prerequisites**

None.
4.50 Course: Combinatorics [T-MATH-105916]

**Responsible:** Prof. Dr. Maria Aksenovich  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102950 - Combinatorics

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**Prerequisites**

none

**Annotation**

The course is offered every second year.

Below you will find excerpts from events related to this course:

**Combinatorics**  
0150300, SS 2024, 4 SWS, [Open in study portal](#)

**Content**

Combinatorics is an area of mathematics primarily concerned with counting finite structures such as sets, groups, and graphs. While combinatorial problems are often very basic and easy to describe, solving them requires special knowledge and skills. This course is devoted to main concepts and techniques in combinatorics. These include counting principles such as inclusion-exclusion and bijective mappings, twelvefold way, generating functions, arrangements, Young tableaux, partitions, recursions, partially ordered sets, extremal set theory, and combinatorial designs.
## 4.51 Course: Communications Engineering II [T-ETIT-110697]

### Responsible:
Dr.-Ing. Holger Jäkel  
Prof. Dr.-Ing. Laurent Schmalen

### Organisation:
KIT Department of Electrical Engineering and Information Technology

### Part of:
M-ETIT-105274 - Communications Engineering II

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### Exams

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

### Competence Certificate
The assessment will be carried out in the form of a written exam of 120 minutes. The module grade is the grade of the written exam.

### Prerequisites
none

### Recommendation
Knowledge of basic engineering mathematics including integral transformations and probability theory as well as basic knowledge of communications engineering.

Previous visit to the lecture “Communications Engineering I”, “Probability Theory” and “Signals and Systems” is recommended.
### 4.52 Course: Comparison Geometry [T-MATH-105917]

**Responsible:** Prof. Dr. Wilderich Tuschmann  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102940 - Comparison Geometry

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**Prerequisites**  
Keine
4.53 Course: Complex Analysis [T-MATH-105849]

**Responsible:**
- PD Dr. Gerd Herzog
- Prof. Dr. Michael Plum
- Prof. Dr. Wolfgang Reichel
- Prof. Dr. Roland Schnaubelt
- Dr. rer. nat. Patrick Tolksdorf

**Organisation:**
KIT Department of Mathematics

**Part of:**
M-MATH-102878 - Complex Analysis

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### 4.54 Course: Complex Geometry [T-MATH-113614]

**Responsible:** Jun.-Prof. Dr. Claudio Llosa Isenrich  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-106776 - Complex Geometry

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**Competence Certificate**
oral exam (ca. 30 min)

**Prerequisites**
none
4.55 Course: Compressive Sensing [T-MATH-105894]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: M-MATH-102935 - Compressive Sensing

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4.56 Course: Computational Economics [T-WIWI-102680]

**Responsible:** Prof. Dr. Pradyumn Kumar Shukla  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics

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**Events**

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**Exams**

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<th>Annotation</th>
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**Competence Certificate**

Please note: the lecture will not take place in the winter semester 2023/2024. Also an exam cannot be offered.

**Prerequisites**

None

**Annotation**

The lecture is currently suspended. An exam cannot be offered.

**Below you will find excerpts from events related to this course:**

**Computational Economics**

2590458, WS 24/25, 2 SWS, Language: English, [Open in study portal]

**Lecture (V)**

Blended (On-Site/Online)

**Content**

Examining complex economic problems with classic analytical methods usually requires making numerous simplifying assumptions, for example that agents behave rationally or homogeneously. Recently, widespread availability of computing power gave rise to a new field in economic research that allows the modeling of heterogeneity and forms of bounded rationality: Computational Economics. Within this new discipline, computer based simulation models are used for analyzing complex economic systems. In short, an artificial world is created which captures all relevant aspects of the problem under consideration. Given all exogenous and endogenous factors, the modelled economy evolves over time and different scenarios can be analyzed. Thus, the model can serve as a virtual testbed for hypothesis verification and falsification.

**Learning objectives:**

The student

- understands the methods of Computational Economics and applies them on practical issues,
- evaluates agent models considering bounded rational behaviour and learning algorithms,
- analyses agent models based on mathematical basics,
- knows the benefits and disadvantages of the different models and how to use them,
- examines and argues the results of a simulation with adequate statistical methods,
- is able to support the chosen solutions with arguments and can explain them.
Literature


Weiterführende Literatur:

Content
The course is held in two parts. The lecture part contains introductions to modeling and simulations, to associated numerical methods, and to associated software and high-performance computer hardware, respectively. The second part is based on supervised group work of the students. Participants work on projects in which modelling, discretization, simulation and evaluation (e.g. visualization) are carried out for specific topics from the catalog. The catalog includes e.g: Diffusion processes, turbulent flows, multiphase flows, reactive flows, particle dynamics, optimal control and optimization under constraints, stabilization methods for advection-dominated transport problems.

At the end of the course, the students are able to jointly model problems beyond their own discipline and simulate them on high-performance computers. They have acquired a critical distance to results and their presentation. They can defend the results of projects in disputes. They have understood the importance of stability, convergence and parallelism of numerical methods from their own experience and are able to evaluate errors in modeling, approximation, computing and presentation.

Basic knowledge of the analysis of boundary value problems and of numerical methods for differential equations is recommended. Knowledge of a programming language is strongly recommended.
### 4.58 Course: Computational Geometry [T-INFO-104429]

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<th>TT-Prof. Dr. Thomas Bläsius</th>
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Mathematics Master 2016 (Master of Science (M.Sc.))
Module Handbook as of 09/07/2024

**Responsible:** Prof. Dr. Michael Plum

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102883 - Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems

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</table>
4.60 Course: Continuous Time Finance [T-MATH-105930]

Responsible: Prof. Dr. Nicole Bäuerle
Prof. Dr. Vicky Fasen-Hartmann
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: M-MATH-102860 - Continuous Time Finance

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Events

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Exams

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Competence Certificate
oral exam of ca. 30 minutes

Prerequisites
none

Below you will find excerpts from events related to this course:

Continuous Time Finance
0159400, SS 2024, 4 SWS, Open in study portal

Course: Continuous Time Finance

Lecture (V)

Content
The lecture covers central topics in continuous-time finance. The first part of the course is an introduction to stochastic analysis. First, we introduce Brownian motion and important topics in the theory of martingales. We then develop the stochastic integral and describe its importance in finance. The second part of the course focuses on the analysis of the Black-Scholes model where the asset process is modelled by a geometric Brownian motion. In this market we price and hedge options. We derive the first and second fundamental theorems of asset pricing, which describe the relationships between arbitrage freedom, equivalent martingale measures and completeness. Finally, we study portfolio optimisation problems and term structure models.

Topics:
- Stochastic processes
- Total variation and quadratic variation
- Ito integral
- Black-Scholes model
- Bonds, futures, term structure models
### 4.61 Course: Control Theory [T-MATH-105909]

**Responsible:** Prof. Dr. Roland Schnaubelt  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102941 - Control Theory

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**Prerequisites**

none
4.62 Course: Convex Analysis [T-WIWI-102856]

- **Responsible:** Prof. Dr. Oliver Stein
- **Organisation:** KIT Department of Economics and Management
- **Part of:** M-WIWI-101473 - Mathematical Programming

### Competence Certificate
The assessment of the lecture is a written examination (60 minutes) according to §4(2), 1 of the examination regulation. The successful completion of the exercises is required for admission to the written exam. The examination is held in the semester of the lecture and in the following semester.

### Prerequisites
None

### Recommendation
It is strongly recommended to visit at least one lecture from the Bachelor program of this chair before attending this course.

### Annotation
The lecture is offered irregularly. The curriculum of the next three years is available online (www.ior.kit.edu).
### 4.63 Course: Convex Geometry [T-MATH-105831]

**Responsible:** Prof. Dr. Daniel Hug  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102864 - Convex Geometry

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Mathematics Master 2016 (Master of Science (M.Sc.))  
Module Handbook as of 09/07/2024
Course: Cooperative Autonomous Vehicles [T-WIWI-112690]

**Responsible:** Prof. Dr. Alexey Vinel

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101472 - Informatics

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**Exams**

| ST 2024   | 79AIFB_CAV_B5 | Cooperative Autonomous Vehicles (Registration until 15 July 2024) | Vinel |

Legend: 🖥 Online, 📜 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

The default assessment of this course is a written examination (60 min).

The exam takes place every semester and can be repeated at every regular examination date.

**Prerequisites**

None.
Course: Corporate Risk Management [T-WIWI-109050]

**Responsible:** Prof. Dr. Martin Ruckes

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101480 - Finance 3
- M-WIWI-101483 - Finance 2
- M-WIWI-101502 - Economic Theory and its Application in Finance

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**Events**

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<th>Grading scale</th>
<th>Recurrence</th>
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**Exams**

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**Competence Certificate**

The assessment consists of a written exam (60 min.) according to § 4 paragraph 2 Nr. 1 of the examination regulation. If there are only a small number of participants registered for the exam, we reserve the right to hold an oral examination instead of a written one.

Please note that the exam is only offered in the semester of the lecture as well as in the following semester.

**Prerequisites**

None

**Recommendation**

None

**Annotation**

The course will be held again in the summer term 2023 at the earliest. Please pay attention to the announcements on our website.

Below you will find excerpts from events related to this course:

2530220, WS 24/25, SWS, Language: English, Open in study portal

**Organizational issues**

Termine nach Ankündigung

**Literature**

4.66 Course: Critical Information Infrastructures [T-WIWI-109248]

**Responsible:** Prof. Dr. Ali Sunyaev  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics

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**Competence Certificate**

The alternative exam assessment consists of

- the preparation of a written elaboration as well as
- an oral examination as part of a presentation of the work.

Details of the grades will be announced at the beginning of the course.

The examination is only offered to first-time students in the winter semester, but can be repeated in the following summer semester.

**Prerequisites**

None.

**Annotation**

Course: Curves on Surfaces [T-MATH-113364]

**Responsible:** Dr. Elia Fioravanti

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-106632 - Curves on Surfaces

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**Competence Certificate**

oral exam (ca. 20-30 min)

**Prerequisites**

none
4.68 Course: Database Systems and XML [T-WIWI-102661]

**Responsible:** Prof. Dr. Andreas Oberweis
**Organisation:** KIT Department of Economics and Management
**Part of:** M-WIWI-101472 - Informatics

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**Exams**

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**Competence Certificate**

The assessment consists of a written exam (60 minutes) (following §4(2) of the examination regulation). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date. Depending on the respective pandemic situation, the exam may be offered as an open book exam (alternative exam assessment, following §4(2), 3 of the examination regulation).

**Prerequisites**

None

Below you will find excerpts from events related to this course:

**Database Systems and XML**

2511202, WS 24/25, 2 SWS, Language: German, Open in study portal

**Lecture (V) Blended (On-Site/Online)**

**Content**

Databases are a proven technology for managing large amounts of data. The oldest database model, the hierarchical model, was replaced by different models such as the relational or the object-oriented data model. The hierarchical model became particularly more important with the emergence of the extensible Markup Language XML. XML is a data format for structured, semi-structured, and unstructured data. In order to store XML documents consistently and reliably, databases or extensions of existing data base systems are required. Among other things, this lecture covers the data model of XML, concepts of XML query languages, aspects of storage of XML documents, and XML-oriented database systems.

**Note on the event format:**

The course Database Systems and XML will be held in WS 23/24 in a "Flipped Classroom" format. Videos and supporting materials are provided for the lecture content, which students can work through independently and at their own pace. During the semester, interactive classroom sessions are held at regular intervals to practice and reinforce the lecture content.

**Learning objectives:**

Students

- know the basics of XML and generate XML documents,
- are able to use XML database systems and to formulate queries to XML documents,
- know to assess the use of XML in operational practice in different application contexts.

**Workload:**

- Lecture 30h
- Exercise 15h
- Preparation of lecture 24h
- Preparation of exercises 25h
- Exam preparation 40h
- Exam 1h
Literature

- W. Kazakos, A. Schmidt, P. Tomchyk: Datenbanken und XML. Springer-Verlag 2002
- G. Vossen: Datenbankmodelle, Datenbanksprachen und Datenbankmanagementsysteme. Oldenbourg 2008

Weitere Literatur wird in der Vorlesung bekannt gegeben.
4.69 Course: Derivatives [T-WIWI-102643]

Responsible: Prof. Dr. Marliese Uhrig-Homburg
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101480 - Finance 3
M-WIWI-101482 - Finance 1
M-WIWI-101483 - Finance 2

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Exams

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Legend: 🖥 Online, 😱 Blended (On-Site/Online), 🗝 On-Site, ☑ Cancelled

Competence Certificate
Depending on further pandemic developments, the examination will be offered either as a 60-minute written examination or as an open-book examination (alternative exam assessment). A bonus can be earned by correctly solving at least 50% of the posed bonus exercises. If the grade of the written examination is between 4.0 and 1.3, the bonus improves the grade by up to one grade level (0.3 or 0.4). Details will be announced in the lecture.

Prerequisites
None

Recommendation
None

Below you will find excerpts from events related to this course:

Literature


Weiterführende Literatur:
4.70 Course: Designtheory with Applications in Statistics [T-MATH-106122]

**Responsible:** Dr. rer. nat. Bruno Ebner  
Dr. Martin Folkers

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-103087 - Designtheory with Applications in Statistics

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Mathematics Master 2016 (Master of Science (M.Sc.))  
Module Handbook as of 09/07/2024
Below you will find excerpts from events related to this course:

**Content**
This course is an introduction to modern differential geometry. Differential geometry is the study of geometry of spaces using analytic and linear algebraic methods. After laying down the foundational definitions and basic properties of smooth manifolds, tangent vectors, and Riemannian metrics, we will develop notions of linear connections and covariant derivatives allowing us to do differential calculus on these manifolds. We will continue our journey of understanding the shape of these manifolds by developing concepts of curvature tensors, geodesics, parallel transport and Jacobi fields. We will also cover the celebrated Bonnet-Myers and Cartan-Hadamard theorems which show us that curvature conditions on a manifold can to some extent dictate the geometry and topology of the manifold.
4.72 Course: Digital Health [T-WIWI-109246]

**Responsible:** Prof. Dr. Ali Sunyaev  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics

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**Events**

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<td>Each winter term</td>
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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

Alternative exam assessment (written elaboration, presentation, peer review, oral participation) according to §4(2),3 of the examination regulation. Details of the grading will be announced at the beginning of the course. The examination is only offered to first-time writers in the winter semester, but can be repeated in the following summer semester.

**Prerequisites**

None.
4.73 Course: Digital Signatures [T-INFO-101280]

**Responsible:** Prof. Dr. Dennis Hofheinz

**Organisation:** KIT Department of Informatics

**Part of:** M-INFO-100743 - Digital Signatures

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<td>Each winter term</td>
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# 4.74 Course: Digital Technology [T-ETIT-101918]

**Responsible:** Prof. Dr.-Ing. Jürgen Becker  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-102102 - Digital Technology

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## Events

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<td>Accompanying group tutorial for 2311615 Digital Technology / Fundamentals of Digital Technology</td>
<td>3 SWS</td>
<td>Lecture / Becker</td>
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<td>WT 24/25</td>
<td>2311615</td>
<td>1 SWS</td>
<td>Practice / Höfer</td>
<td>Tutorial for 2311615 Digital Technology / Fundamentals of Digital Technology</td>
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## Exams

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<td>Digital Technology</td>
<td>Becker</td>
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**Prerequisites**
none
4.75 Course: Discrete Dynamical Systems [T-MATH-110952]

**Responsible:** PD Dr. Gerd Herzog

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105432 - Discrete Dynamical Systems

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**Prerequisites**

none
4 COURSES

Course: Discrete Time Finance [T-MATH-105839]

4.76 Course: Discrete Time Finance [T-MATH-105839]

**Responsible:** Prof. Dr. Nicole Bäuerle
Prof. Dr. Vicky Fasen-Hartmann
Prof. Dr. Mathias Trabs

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102919 - Discrete Time Finance

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**Events**

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<td>Finanzmathematik in diskreter Zeit</td>
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Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

**Competence Certificate**
Written exam of 2h.

**Prerequisites**
none

**Recommendation**
The contents of the module „Probability theory“ are strongly recommended.
Course: Discrete-Event Simulation in Production and Logistics [T-WIWI-102718]

**Responsible:** Hon.-Prof. Dr. Sven Spieckermann

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-102832 - Operations Research in Supply Chain Management

**Type:** Examination of another type  
**Credits:** 4,5  
**Grading scale:** Grade to a third  
**Recurrence:** Each summer term  
**Version:** 2

**Events**

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**Exams**

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Legend: 📱 Online, 🛠 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**
The assessment consists of a written paper and an oral exam of about 30-40 min (alternative exam assessment).

**Prerequisites**
None

**Recommendation**
Basic knowledge as conveyed in the module "Introduction to Operations Research" is assumed.

**Annotation**
Due to capacity restrictions, registration before course start is required. For further information see the webpage of the course.

The course is planned to be held every summer term.

The planned lectures and courses for the next three years are announced online.

Below you will find excerpts from events related to this course:

**Ereignisdiskrete Simulation in Produktion und Logistik**

<table>
<thead>
<tr>
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<td>3</td>
<td>Lecture / On-Site</td>
<td>Spieckermann</td>
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</table>

**Content**
Simulation of production and logistics systems is an interdisciplinary subject connecting expert knowledge from production management and operations research with mathematics/statistics as well as computer science and software engineering. With completion of this course, students know statistical foundations of discrete simulation, are able to classify and apply related software applications, and know the relation between simulation and optimization as well as a number of application examples. Furthermore, students are enabled to structure simulation studies and are aware of specific project scheduling issues.

**Organizational issues**
Den Bewerbungszeitraum finden Sie auf der Veranstaltungswebseite im Lehre-Bereich unter doi.ior.kit.edu
Literature

4.78 Course: Dispersive Equations [T-MATH-109001]

**Responsible:** Prof. Dr. Wolfgang Reichel

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-104425 - Dispersive Equations

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**Prerequisites**

none
## 4.79 Course: Distributed Discrete Event Systems [T-ETIT-100960]

**Responsible:** Prof. Dr.-Ing. Michael Heizmann  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100361 - Distributed Discrete Event Systems

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### Events

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### Exams

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

### Prerequisites

none
### 4.80 Course: Dynamic Macroeconomics [T-WIWI-109194]

**Responsible:** Prof. Dr. Johannes Brumm  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101496 - Growth and Agglomeration

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<td>Each winter term</td>
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**Competence Certificate**  
The assessment is a written exam (60 min.).

**Prerequisites**  
None.
4.81 Course: Dynamical Systems [T-MATH-106114]

**Responsible:** Prof. Dr. Wolfgang Reichel

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-103080 - Dynamical Systems

**Type:** Oral examination

**Credits:** 8

**Grading scale:** Grade to a third

**Recurrence:** Irregular

**Version:** 1

**Prerequisites:**
none
4.82 Course: Efficient Energy Systems and Electric Mobility [T-WIWI-102793]

Responsible: Prof. Dr. Patrick Jochem
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101452 - Energy Economics and Technology

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Events

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<td>2 SWS</td>
<td>Lecture / On-Site</td>
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Exams

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<td>Efficient Energy Systems and Electric Mobility</td>
<td>Fichtner</td>
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</table>

Competence Certificate

The assessment consists of a written exam (60 minutes) (following §4(2) of the examination regulation). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date. Depending on the respective pandemic situation, the exam may be offered as an open book exam (alternative exam assessment, following §4(2), 3 of the examination regulation).

Prerequisites
None

Recommendation
None

Below you will find excerpts from events related to this course:

Efficient Energy Systems and Electric Mobility
2581006, SS 2024, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content

This lecture series combines two of the most central topics in the field of energy economics at present, namely energy efficiency and electric mobility. The objective of the lecture is to provide an introduction and overview to these two subject areas, including theoretical as well as practical aspects, such as the technologies, political framework conditions and broader implications of these for national and international energy systems.

- Understand the concept of energy efficiency as applied to specific systems
- Obtain an overview of the current trends in energy efficiency
- Be able to determine and evaluate alternative methods of energy efficiency improvement
- Overview of technical and economical stylized facts on electric mobility
- Judging economical, ecological and social impacts through electric mobility

Organizational issues

s. Institutsauskang

Literature

Wird in der Vorlesung bekanntgegeben.
**4.83 Course: eFinance: Information Systems for Securities Trading [T-WIWI-110797]**

**Responsible:** Prof. Dr. Christof Weinhardt  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101480 - Finance 3  
M-WIWI-101483 - Finance 2

**Type**  
Written examination  
**Credits**  
4,5  
**Grading scale**  
Grade to a third  
**Recurrence**  
Each winter term  
**Version**  
1

**Events**

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**Exams**

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

Success is monitored by means of ongoing elaborations and presentations of tasks and an examination (60 minutes) at the end of the lecture period. The scoring scheme for the overall evaluation will be announced at the beginning of the course.

**Annotation**

The course"eFinance: Information Systems for Securities Trading" covers different actors and their function in the securities industry in-depth, highlighting key trends in modern financial markets, such as Distributed Ledger Technology, Sustainable Finance, and Artificial Intelligence. Security prices evolve through a large number of bilateral trades, performed by market participants that have specific, well-regulated and institutionalized roles. Market microstructure is the subfield of financial economics that studies the price formation process. This process is significantly impacted by regulation and driven by technological innovation. Using the lens of theoretical economic models, this course reviews insights concerning the strategic trading behaviour of individual market participants, and models are brought market data. Analytical tools and empirical methods of market microstructure help to understand many puzzling phenomena in securities markets.

*Below you will find excerpts from events related to this course:*

**Literature**


**Weiterführende Literatur:**

4.84 Course: Eigenvalue Problems in Complicated Domains [T-MATH-106497]

**Responsible:** Dr. Andrii Khrabustovskyi

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-103262 - Eigenvalue Problems in Complicated Domains

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**Prerequisites**

Keine
4.85 Course: Elective Module - Subject, Body, Individual: the Other Side of Sustainability - Self Assignment BeNe [T-ZAK-112349]

Organisation:
Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

Type
Examination of another type

Credits
3

Grading scale
Grade to a third

Version
1

Competence Certificate
Examination of another kind according to § 7 section 7 in the form of a presentation in the selected course.

Prerequisites
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

Self service assignment of supplementary studies
This course can be used for self service assignment of grade acquired from the following study providers:

• Zentrum für Angewandte Kulturwissenschaft und Studium Generale
• ZAK Begleitstudium

Recommendation
The content of the Basics Module is helpful.
4.86 Course: Elective Module - Sustainability Assessment of Technology - Self Assignment BeNe [T-ZAK-112348]

**Organisation:**
- Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

**Type**
- Examination of another type

**Credits**
- 3

**Grading scale**
- Grade to a third

**Version**
- 1

**Competence Certificate**
Examination of another kind according to § 7 section 7 in the form of a presentation in the selected course.

**Prerequisites**
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

**Self service assignment of supplementary studies**
This course can be used for self service assignment of grade acquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

**Recommendation**
The content of the Basics Module is helpful.
4.87 Course: Elective Module - Sustainability in Culture, Economy and Society - Self Assignment BeNe [T-ZAK-112350]

Organisation:
Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

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Competence Certificate
Examination of another kind according to § 7 section 7 in the form of a presentation in the selected course.

Prerequisites
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

Self service assignment of supplementary studies
This course can be used for self service assignment of grade acquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Recommendation
The content of the Basics Module is helpful.
4.88 Course: Elective Module - Sustainable Cities and Neighbourhoods - Self Assignment BeNe [T-ZAK-112347]

**Organisation:** University

**Part of:** M-ZAK-106099 - Supplementary Studies on Sustainable Development

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**Competence Certificate**
Examination of another kind according to § 7 section 7 in the form of a presentation in the selected course.

**Prerequisites**
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

**Self service assignment of supplementary studies**
This course can be used for self service assignment of grade acquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

**Recommendation**
The content of the Basics Module is helpful.
# 4.89 Course: Electromagnetics and Numerical Calculation of Fields [T-ETIT-100640]

**Responsible:** Prof. Dr.-Ing. Thomas Zwick  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100386 - Electromagnetics and Numerical Calculation of Fields  

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## Events

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## Exams

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*Legend: Online, Blended (On-Site/Online), On-Site, Cancelled*

**Competence Certificate**  
Success control is carried out in the form of a written test of 120 minutes.

**Prerequisites**  
none

**Recommendation**  
Fundamentals of electromagnetic field theory.
4.90 Course: Emerging Trends in Digital Health [T-WIWI-110144]

**Responsible:** Prof. Dr. Ali Sunyaev

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101472 - Informatics

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**Events**

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**Competence Certificate**

The alternative exam assessment consists of a final thesis.

**Prerequisites**

None.

**Annotation**

The course is usually held as a block course.
### 4.91 Course: Emerging Trends in Internet Technologies [T-WIWI-110143]

- **Responsible:** Prof. Dr. Ali Sunyaev
- **Organisation:** KIT Department of Economics and Management
- **Part of:** M-WIWI-101472 - Informatics

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**Exams**

| ST 2024 | 7900128 | Seminar Emerging Trends in Internet Technologies (Master) | Sunyaev |

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

### Competence Certificate
The alternative exam assessment consists of a final thesis.

### Prerequisites
None.

### Annotation
The course is usually held as a block course.
4.92 Course: Energy and Environment [T-WIWI-102650]

**Responsible:** Ute Karl  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101452 - Energy Economics and Technology  

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**Exams**

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**Legend:** 🖥 Online, ☠ Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

The assessment consists of a written exam (60 minutes) (following §4(2) of the examination regulation). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date. Depending on the respective pandemic situation, the exam may be offered as an open book exam (alternative exam assessment, following §4(2), 3 of the examination regulation).

**Prerequisites**

None.

**Below you will find excerpts from events related to this course:**

**Content**

The lecture focuses on the environmental impacts arising from fossil fuels use and on the methods for the evaluation of such impacts. The first part of the lecture describes the environmental impacts of air pollutants and greenhouse gases as well as technical measures for emission control. The second part covers methods of impact assessment and their use in environmental communication as well as methods for the scientific support of emission control strategies.

The topics include:

- Fundamentals of energy conversion  
- Formation of air pollutants during combustion  
- Technical measures to control emissions from fossil-fuel combustion processes  
- External effects of energy supply (life cycle analyses of selected energy systems)  
- Environmental communication on energy services (e.g. electricity labelling, carbon footprint)  
- Integrated Assessment Modelling to support the European Clean Air Strategy  
- Cost-effectiveness analyses and cost-benefit analyses for emission control strategies  
- Monetary valuation of external effects (external costs)

**Literature**

Die Literaturhinweise sind in den Vorlesungsunterlagen enthalten (vgl. ILIAS)
4.93 Course: Ergodic Theory [T-MATH-113086]

**Responsible:** Dr. Gabriele Link

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-106473 - Ergodic Theory

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**Exams**

| ST 2024 | 7700114 | Ergodic Theory | Link |

**Competence Certificate**

Oral examination of ca. 20-30 minutes.

**Prerequisites**

none

**Recommendation**

Some basic knowledge of measure theory, topology, geometry, group theory and functional analysis is recommended.
4.94 Course: Evolution Equations [T-MATH-105844]

**Responsible:** Prof. Dr. Dorothee Frey
apl. Prof. Dr. Peer Kunstmann
Prof. Dr. Roland Schnaubelt

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102872 - Evolution Equations

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**Exams**

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</table>
# 4.95 Course: Experimental Economics [T-WIWI-102614]

**Responsible:** Prof. Dr. Christof Weinhardt  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-102970 - Decision and Game Theory  

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## Exams

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**  
The assessment consists of a written exam (60 min).

**Prerequisites**  
None

**Below you will find excerpts from events related to this course:**

## Lecture (V)

**Experimental Economics**  
2540489, WS 24/25, 2 SWS, Language: German, [Open in study portal](#)

## Literature

- Strategische Spiele; S. Berninghaus, K.-M. Ehrhart, W. Güth; Springer Verlag, 2. Aufl. 2006.
- Experimental Methods: A Primer for Economists; D. Friedman, S. Sunder; Cambridge University Press, 1994.
### 4.96 Course: Exponential Integrators [T-MATH-107475]

**Responsible:** Prof. Dr. Marlis Hochbruck  
Prof. Dr. Tobias Jahnke  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-103700 - Exponential Integrators

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**Prerequisites:**  
none
### 4.97 Course: Extremal Graph Theory [T-MATH-105931]

**Responsible:** Prof. Dr. Maria Aksenovich  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102957 - Extremal Graph Theory

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**Prerequisites**
none
### 4.98 Course: Extreme Value Theory [T-MATH-105908]

**Responsible:** Prof. Dr. Vicky Fasen-Hartmann  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102939 - Extreme Value Theory

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| Events |       |                           |         |         |
|--------|-------|---------------------------|---------|
| ST 2024| 0155600 | Extremwertheorie         | 2 SWS   | Lecture |
| ST 2024| 0155610 | Übungen zu 0155600 (Extremwertheorie) | 1 SWS   | Practice|

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Course: Facility Location and Strategic Supply Chain Management [T-WIWI-102704]

Responsible: Prof. Dr. Stefan Nickel
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101413 - Applications of Operations Research
M-WIWI-101414 - Methodical Foundations of OR

Type: Written examination
Credits: 4,5
Grading scale: Grade to a third
Recurrence: Each winter term
Version: 4

Events
WT 24/25 2550486 Facility Location and Strategic Supply Chain Management 2 SWS Lecture / On-Site Nickel
WT 24/25 2550487 Exercises for Facility Location and Strategic Supply Chain Management 1 SWS Practice / On-Site Hoffmann

Exams
ST 2024 7900027 Facility Location and Strategic Supply Chain Management Nickel
WT 24/25 7900091 Facility Location and Strategic Supply Chain Management Nickel

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

Competence Certificate
The assessment consists of a written exam (60 min) according to Section 4 (2), 1 of the examination regulation. The exam takes place in every semester. Prerequisite for admission to examination is the successful completion of the online assessments.

Prerequisites
Prerequisite for admission to examination is the successful completion of the online assessments.

Recommendation
None

Annotation
The lecture is held in every winter term. The planned lectures and courses for the next three years are announced online.

Below you will find excerpts from events related to this course:

V Facility Location and Strategic Supply Chain Management
2550486, WS 24/25, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

Organizational issues

Literature
Weiterführende Literatur:

- Love, Morris, Wesolowsky: Facilities Location: Models and Methods, North Holland, 1988
Course: Financial Analysis [T-WIWI-102900]

**Responsible:** Dr. Torsten Luedecke

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101480 - Finance 3
- M-WIWI-101483 - Finance 2

**Type**: Written examination  
**Credits**: 4,5  
**Grading scale**: Grade to a third  
**Recurrence**: Each summer term  
**Version**: 1

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**Competence Certificate**
See German version.

**Prerequisites**
None

**Recommendation**
Basic knowledge in corporate finance, accounting, and valuation is required.

Below you will find excerpts from events related to this course:

**Financial Analysis**
2530205, SS 2024, 2 SWS, Language: German, [Open in study portal](#)

**Literature**
4.101 Course: Financial Intermediation [T-WIWI-102623]

- **Responsible:** Prof. Dr. Martin Ruckes
- **Organisation:** KIT Department of Economics and Management
- **Part of:**
  - M-WIWI-101480 - Finance 3
  - M-WIWI-101483 - Finance 2
  - M-WIWI-101502 - Economic Theory and its Application in Finance

### Events

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

### Exams

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### Competence Certificate

The assessment of this course is a written examination (following §4(2), 1 SPO) of 60 mins. The exam is offered each semester.

### Prerequisites

None

### Recommendation

None

Below you will find excerpts from events related to this course:

#### Financial Intermediation

2530232, WS 24/25, 2 SWS, Language: German, Open in study portal

**Lecture (V) On-Site**

### Organizational issues

Terminankündigungen des Instituts beachten

### Literature

**Weiterführende Literatur:**

Below you will find excerpts from events related to this course:

### Finite Element Methods

#### 0110300, WS 24/25, 4 SWS, Open in study portal

Lecture (V)
Below you will find excerpts from events related to this course:

**Forecasting: Theory and Praxis**
0123100, WS 24/25, 2 SWS, Open in study portal

**Content**
A common desire of all humankind is to make predictions for the future. As the future is inherently uncertain, forecasts ought to be probabilistic, i.e., they ought to take the form of probability distributions over future quantities or events. In this class, which is Part I of a two semester series, we will study the probabilistic and statistical foundations of the science of forecasting.

The goal in probabilistic forecasting is to maximize the sharpness of the predictive distributions subject to calibration, based on the information set at hand. Proper scoring rules such as the logarithmic score and the continuous ranked probability score serve to assess calibration and sharpness simultaneously, and relate to information theory and convex analysis. As a special case, consistent scoring functions provide decision-theoretically coherent tools for evaluating point forecasts. Throughout, concepts and methodologies will be illustrated in data examples and case studies.
### 4.104 Course: Formal Systems [T-INFO-101336]

**Responsible:** Prof. Dr. Bernhard Beckert  
**Organisation:** KIT Department of Informatics  
**Part of:** M-INFO-100799 - Formal Systems

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</table>
4.105 Course: Foundations of Continuum Mechanics [T-MATH-107044]

**Responsible:** Prof. Dr. Christian Wieners

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-103527 - Foundations of Continuum Mechanics

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**Prerequisites**

none
Course: Fourier Analysis and its Applications to PDEs [T-MATH-109850]

**Responsible:** TT-Prof. Dr. Xian Liao

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-104827 - Fourier Analysis and its Applications to PDEs

**Type:** Oral examination

**Credits:** 6

**Grading scale:** Grade to a third

**Recurrence:** Irregular

**Version:** 3

**Prerequisites**

none
4.107 Course: Fractal Geometry [T-MATH-111296]

**Responsible:** PD Dr. Steffen Winter

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105649 - Fractal Geometry

**Type**
- Oral examination

**Credits**
- 6

**Grading scale**
- Grade to a third

**Recurrence**
- Irregular

**Version**
- 1

**Prerequisites**
- none


### Course: Functional Analysis [T-MATH-102255]

**Responsible:**
- Prof. Dr. Dorothee Frey
- PD Dr. Gerd Herzog
- Prof. Dr. Dirk Hundertmark
- Prof. Dr. Tobias Lamm
- TT-Prof. Dr. Xian Liao
- Prof. Dr. Wolfgang Reichel
- Prof. Dr. Roland Schnaubelt
- Dr. rer. nat. Patrick Tolksdorf

**Organisation:**
- KIT Department of Mathematics

**Part of:**
- M-MATH-101320 - Functional Analysis

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**Legend:**
- Online
- Blended (On-Site/Online)
- On-Site
- Cancelled

**Competence Certificate**

Written examination of 120 minutes.

**Prerequisites**

none

**Below you will find excerpts from events related to this course:**

**Functional Analysis**

0104800, WS 24/25, 4 SWS, Open in study portal

**Lecture (V)**

On-Site

### Content

The lecture deals with Banach and Hilbert spaces and the linear operators on these spaces. Typical examples are spaces of continuous or integrable functions, and linear operators on these spaces occur in the study of integral and differential equations. The development of functional analysis in the 20th century contributed significantly to the modern theory of differential equations. Today, functional analysis is a fundamental discipline of modern analysis and is widely used, for example, in the theory of partial differential equations, numerical mathematics, mathematical physics and many other areas of application.

Topics of the lecture:
- basic properties and examples of metric spaces and Banach spaces,
- continuous linear operators on Banach spaces,
- uniform boundedness principle,
- homomorphism theorem,
- Hilbert spaces,
- orthonormal bases,
- Sobolev spaces,
- dual spaces,
- Hahn-Banach theorem,
- weak convergence,
- Banach-Alaoglu theorem,
- reflexivity,
- compact linear operators.

The contents of the basic lectures Analysis 1-3 and Linear Algebra 1+2 are assumed.
Literature

- D. Werner: Funktionalanalysis.
- J.B. Conway: A Course in Functional Analysis.
- M. Reed, B. Simon: Functional Analysis.
- J. Wloka: Funktionalanalysis und Anwendungen.
4 COURSES

T 4.109 Course: Functional Data Analysis [T-MATH-113102]

**Responsible:** Dr. rer. nat. Bruno Ebner
              PD Dr. Bernhard Klar
              Prof. Dr. Mathias Trabs

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-106485 - Functional Data Analysis

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**Competence Certificate**

Oral examination of ca. 25 minutes.

**Prerequisites**

none

**Recommendation**

The contents of the modules "Probability Theory" and "Mathematical Statistics" are strongly recommended.
4.110 Course: Functions of Matrices [T-MATH-105906]

**Responsible:** PD Dr. Volker Grimm

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102937 - Functions of Matrices

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**Exams**

| ST 2024 | 00054 | Functions of Matrices | Grimm   |

**Prerequisites**

none
4.111 Course: Functions of Operators [T-MATH-105905]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102936 - Functions of Operators

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4.112 Course: Fuzzy Sets [T-INFO-101376]

**Responsible:** Prof. Dr.-Ing. Uwe Hanebeck

**Organisation:** KIT Department of Informatics

**Part of:** M-INFO-100839 - Fuzzy Sets

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# 4.113 Course: Generalized Regression Models [T-MATH-105870]

**Responsible:**
- Dr. rer. nat. Bruno Ebner
- Prof. Dr. Vicky Fasen-Hartmann
- PD Dr. Bernhard Klar
- Prof. Dr. Mathias Trabs

**Organisation:**
KIT Department of Mathematics

**Part of:**
M-MATH-102906 - Generalized Regression Models

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4.114 Course: Geometric Analysis [T-MATH-105892]

**Responsible:** Prof. Dr. Tobias Lamm

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102923 - Geometric Analysis

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**Prerequisites**

none
Below you will find excerpts from events related to this course:

**Geometric Group Theory**

0153300, SS 2024, 4 SWS, Language: English, [Open in study portal](#)

**Lecture (V)**

Content

This course will provide an introduction to geometric group theory, which studies the interactions between finitely generated groups and geometric spaces, creating connections between algebra and geometry. While a priori groups may seem like purely algebraic objects, they can naturally arise as symmetries of geometric objects. For instance, the symmetries of a regular n-gon form a group (the dihedral group $D_n$). In fact, every finitely generated group admits a natural action by isometries on a metric space, known as its Cayley graph. For instance the Cayley graph of the integers is the real line with vertices given by the integer points and the group action defined by translation.

Studying group actions on geometric spaces, allows us to gain insights into "the geometry of groups". Conversely, knowing that a geometric space admits an interesting group action allows us to obtain a better understanding of the space itself. Over the last decades, these interactions between group theory and geometry have led to an array of fundamental results in both areas. This course will provide an introduction to these interactions and their consequences.

In particular, we will learn about

- finitely generated groups and group presentations
- Cayley graphs and group actions
- quasi-isometries of metric spaces, quasi-isometry invariants and the Theorem of Schwarz-Milnor
- explicit examples of infinite groups and their connections to geometry

Prerequisites are:

Knowledge of the basic concepts on metric and topological spaces, as well as some familiarity with the basic concepts in group theory are recommended.
### 4.116 Course: Geometric Group Theory II [T-MATH-105875]

**Responsible:**  
Prof. Dr. Frank Herrlich  
Jun.-Prof. Dr. Claudio Llosa Isenrich  
Prof. Dr. Roman Sauer

**Organisation:**  
KIT Department of Mathematics

**Part of:**  
M-MATH-102869 - Geometric Group Theory II

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4.117 Course: Geometric Numerical Integration [T-MATH-105919]

**Responsible:** Prof. Dr. Marlis Hochbruck  
Prof. Dr. Tobias Jahnke

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102921 - Geometric Numerical Integration

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**Prerequisites**
none
4.118 Course: Geometric Variational Problems [T-MATH-113418]

**Responsible:** Prof. Dr. Tobias Lamm

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-106667 - Geometric Variational Problems

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**Exams**

| ST 2024 | 7700133 | Geometric Variational Problems | Lamm |

**Competence Certificate**

oral exam of ca. 30 min

**Prerequisites**

none
4.119 Course: Geometry of Schemes [T-MATH-105841]

**Responsible:** Prof. Dr. Frank Herrlich
PD Dr. Stefan Kühnlein

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102866 - Geometry of Schemes

<table>
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<td>Geometrie der Schemata</td>
<td>4 SWS</td>
<td>Lecture</td>
<td>Herrlich</td>
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<td>WT 24/25 0102700</td>
<td>Übungen zu 0102600 (Geometrie der Schemata)</td>
<td>2 SWS</td>
<td>Practice</td>
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4.120 Course: Global Differential Geometry [T-MATH-105885]

**Responsible:** Prof. Dr. Wilderich Tuschmann

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102912 - Global Differential Geometry

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<td>Grade to a third</td>
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**Prerequisites**

none
4 COURSES

# 4.121 Course: Global Optimization I [T-WIWI-102726]

**Responsible:** Prof. Dr. Oliver Stein  
**Organisation:** KIT Department of Economics and Management  
**Part of:**  
- M-WIWI-101413 - Applications of Operations Research  
- M-WIWI-101414 - Methodical Foundations of OR  
- M-WIWI-101473 - Mathematical Programming

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## Competence Certificate
Success is in the form of a written examination (60 min.) (according to § 4(2), 1 SPO). The successful completion of the exercises is required for admission to the written exam.

The exam is offered in the lecture of semester and the following semester.

The success check can be done also with the success control for "Global optimization II". In this case, the duration of the written exam is 120 min.

## Prerequisites
None

## Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-WIWI-103638 - Global Optimization I and II must not have been started.

## Recommendation
None

## Annotation
Part I and II of the lecture are held consecutively in the same semester.

Below you will find excerpts from events related to this course:

**Global Optimization I**  
2550134, SS 2024, 2 SWS, Language: German, Open in study portal
Content
In many optimization problems from economics, engineering and natural sciences, solution algorithms are only able to efficiently identify local optimizers, while it is much harder to find globally optimal points. This corresponds to the fact that by local search it is easy to find the summit of the closest mountain, but that the search for the summit of Mount Everest is rather elaborate.

The lecture treats methods for global optimization of convex functions under convex constraints. It is structured as follows:

- Introduction, examples, and terminology
- Existence results for optimal points
- Optimality in convex optimization
- Duality, bounds, and constraint qualifications
- Algorithms (Kelley's cutting plane method, Frank-Wolfe method, primal-dual interior point methods)

The lecture is accompanied by exercises which, amongst others, offers the opportunity to implement and to test some of the methods on practically relevant examples.

Remark:
The treatment of nonconvex optimization problems forms the contents of the lecture “Global Optimization II”. The lectures "Global Optimization I" and "Global Optimization II" are held consecutively in the same semester.

Learning objectives:
The student

- knows and understands the fundamentals of deterministic global optimization in the convex case,
- is able to choose, design and apply modern techniques of deterministic global optimization in the convex case in practice.

Literature

Weiterführende Literatur:

- W. Alt, Numerische Verfahren der konvexen, nichtglatten Optimierung, Teubner, 2004
- C.A. Floudas, Deterministic Global Optimization, Kluwer, 2000
4.122 Course: Global Optimization I and II [T-WIWI-103638]

**Responsible:** Prof. Dr. Oliver Stein  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101414 - Methodical Foundations of OR  
M-WIWI-101473 - Mathematical Programming

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**Events**

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<td>ST 2024</td>
<td>2550135</td>
<td>Exercise to Global Optimization I and II</td>
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<td>Stein, Beck</td>
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<td>2550136</td>
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**Exams**

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<td>WT 24/25</td>
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</table>

Legend: 🖥 Online, 🧱 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Competence Certificate**

The assessment of the lecture is a written examination (120 minutes) according to §4(2), 1 of the examination regulation. The successful completion of the exercises is required for admission to the written exam. The examination is held in the semester of the lecture and in the following semester.

**Prerequisites**

None

**Modeled Conditions**

The following conditions have to be fulfilled:

1. The course T-WIWI-102726 - Global Optimization I must not have been started.
2. The course T-WIWI-102727 - Global Optimization II must not have been started.

**Recommendation**

None

**Annotation**

Part I and II of the lecture are held consecutively in the same semester.

**Below you will find excerpts from events related to this course:**

<table>
<thead>
<tr>
<th>Events</th>
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<td>V</td>
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<td>Global Optimization I</td>
<td>2 SWS</td>
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Lecture (V)

On-Site
Content
In many optimization problems from economics, engineering and natural sciences, solution algorithms are only able to efficiently identify local optimizers, while it is much harder to find globally optimal points. This corresponds to the fact that by local search it is easy to find the summit of the closest mountain, but that the search for the summit of Mount Everest is rather elaborate.

The lecture treats methods for global optimization of convex functions under convex constraints. It is structured as follows:

- Introduction, examples, and terminology
- Existence results for optimal points
- Optimality in convex optimization
- Duality, bounds, and constraint qualifications
- Algorithms (Kelley's cutting plane method, Frank-Wolfe method, primal-dual interior point methods)

The lecture is accompanied by exercises which, amongst others, offers the opportunity to implement and to test some of the methods on practically relevant examples.

Remark:
The treatment of nonconvex optimization problems forms the contents of the lecture "Global Optimization II". The lectures "Global Optimization I" and "Global Optimization II" are held consecutively in the same semester.

Learning objectives:
The student

- knows and understands the fundamentals of deterministic global optimization in the convex case,
- is able to choose, design and apply modern techniques of deterministic global optimization in the convex case in practice.

Literature

Weiterführende Literatur:

- W. Alt, Numerische Verfahren der konvexen, nichtglatten Optimierung, Teubner, 2004
- C.A. Floudas, Deterministic Global Optimization, Kluwer, 2000

Global Optimization II

2550136, SS 2024, 2 SWS, Language: German, Open in study portal

Content
In many optimization problems from economics, engineering and natural sciences, solution algorithms are only able to efficiently identify local optimizers, while it is much harder to find globally optimal points. This corresponds to the fact that by local search it is easy to find the summit of the closest mountain, but that the search for the summit of Mount Everest is rather elaborate.

The lecture treats methods for global optimization of nonconvex functions under nonconvex constraints. It is structured as follows:

- Introduction and examples
- Convex relaxation
- Interval arithmetic
- Convex relaxation via alphaBB method
- Branch-and-bound methods
- Lipschitz optimization

The lecture is accompanied by exercises which, amongst others, offers the opportunity to implement and to test some of the methods on practically relevant examples.

Remark:
The treatment of convex optimization problems forms the contents of the lecture "Global Optimization I". The lectures "Global Optimization I" and "Global Optimization II" are held consecutively in the same semester.

Learning objectives:
The student

- knows and understands the fundamentals of deterministic global optimization in the nonconvex case,
- is able to choose, design and apply modern techniques of deterministic global optimization in the nonconvex case in practice.
**Literature**

**Weiterführende Literatur:**
- W. Alt, Numerische Verfahren der konvexen, nichtglatten Optimierung, Teubner, 2004
- C.A. Floudas, Deterministic Global Optimization, Kluwer, 2000
Course: Global Optimization II [T-WIWI-102727]

**Responsible:** Prof. Dr. Oliver Stein  
**Organisation:** KIT Department of Economics and Management  
**Part of:**  
- M-WIWI-101414 - Methodical Foundations of OR  
- M-WIWI-101473 - Mathematical Programming

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗂 On-Site, ☠ Cancelled

**Competence Certificate**
The assessment of the lecture is a written examination (60 minutes) according to §4(2), 1 of the examination regulation. The successful completion of the exercises is required for admission to the written exam.

The examination is held in the semester of the lecture and in the following semester.

The examination can also be combined with the examination of "Global optimization I". In this case, the duration of the written examination takes 120 minutes.

**Prerequisites**
None

**Modeled Conditions**
The following conditions have to be fulfilled:

1. The course T-WIWI-103638 - Global Optimization I and II must not have been started.

**Annotation**
Part I and II of the lecture are held consecutively in the same semester.

*Below you will find excerpts from events related to this course:*

**Global Optimization II**
2550136, SS 2024, 2 SWS, Language: German, [Open in study portal](#)
Content
In many optimization problems from economics, engineering and natural sciences, solution algorithms are only able to efficiently identify local optimizers, while it is much harder to find globally optimal points. This corresponds to the fact that by local search it is easy to find the summit of the closest mountain, but that the search for the summit of Mount Everest is rather elaborate.

The lecture treats methods for global optimization of nonconvex functions under nonconvex constraints. It is structured as follows:

- Introduction and examples
- Convex relaxation
- Interval arithmetic
- Convex relaxation via alphaBB method
- Branch-and-bound methods
- Lipschitz optimization

The lecture is accompanied by exercises which, amongst others, offers the opportunity to implement and to test some of the methods on practically relevant examples.

Remark:
The treatment of convex optimization problems forms the contents of the lecture "Global Optimization I". The lectures "Global Optimization I" and "Global Optimization II" are held consecutively in the same semester.

Learning objectives:
The student

- knows and understands the fundamentals of deterministic global optimization in the nonconvex case,
- is able to choose, design and apply modern techniques of deterministic global optimization in the nonconvex case in practice.

Literature

Weiterführende Literatur:
- W. Alt, Numerische Verfahren der konvexen, nichtglatten Optimierung, Teubner, 2004
- C.A. Floudas, Deterministic Global Optimization, Kluwer, 2000
### 4.124 Course: Graph Theory [T-MATH-102273]

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<tr>
<th>Responsible:</th>
<th>Prof. Dr. Maria Aksenovich</th>
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<td>KIT Department of Mathematics</td>
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<td>Aksenovich</td>
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### Prerequisites
None
Course: Graph Theory and Advanced Location Models [T-WWI-102723]

**Responsible:** Prof. Dr. Stefan Nickel

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WWI-101473 - Mathematical Programming
- M-WWI-102832 - Operations Research in Supply Chain Management

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**Exams**

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<th>Instructor</th>
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<td>7900283</td>
<td>Graph Theory and Advanced Location Models</td>
<td>Nickel</td>
</tr>
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**Competence Certificate**

The assessment is a 60 minutes written examination (according to §4(2), 1 of the examination regulation). The examination is held in the term of the lecture and the following lecture.

**Prerequisites**

None

**Recommendation**

Basic knowledge as conveyed in the module "Introduction to Operations Research" is assumed.

**Annotation**

The course is offered irregularly. Planned lectures for the next three years can be found in the internet at http://doLior.kit.edu/english/Courses.php.
4.126 Course: Group Actions in Riemannian Geometry [T-MATH-105925]

**Responsible:** Prof. Dr. Wilderich Tuschmann

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102954 - Group Actions in Riemannian Geometry

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**Prerequisites**
none
4.127 Course: Growth and Development [T-WIWI-112816]

**Responsible:** Prof. Dr. Ingrid Ott

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101496 - Growth and Agglomeration

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**Events**

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<th>Credits</th>
<th>Grade to a third</th>
<th>Recurrence</th>
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<td>2561503</td>
<td>Growth and Development</td>
<td>Lecture</td>
<td>2 SWS</td>
<td>Grade to a third</td>
<td>Each winter term</td>
<td>Ott</td>
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<td>WT 24/25</td>
<td>2561504</td>
<td>Exercise for Growth and Development</td>
<td>Practice</td>
<td>1 SWS</td>
<td>Grade to a third</td>
<td>Each winter term</td>
<td>Ott, Zoroglu</td>
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**Exams**

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗄 On-Site, ❌ Cancelled

**Competence Certificate**

Depending on further pandemic developments, the examination will be offered either as an open-book examination or as a 60-minute written examination.

**Prerequisites**

None

**Recommendation**

Basic knowledge of micro- and macroeconomics is assumed, as taught in the courses Economics I [2600012], and Economics II [2600014]. In addition, an interest in quantitative-mathematical modeling is required.

**Below you will find excerpts from events related to this course:**

**Growth and Development**

<table>
<thead>
<tr>
<th>Event Code</th>
<th>Type</th>
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<th>Language</th>
<th>Open in study portal</th>
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<tbody>
<tr>
<td>2561503</td>
<td>Lecture</td>
<td>24/25</td>
<td>2 SWS</td>
<td>German/English</td>
<td>Open in study portal</td>
</tr>
</tbody>
</table>


Content
This course is intended as an introduction to the field of advanced macroeconomics with a special focus on economic growth. Lectures aim to deal with the theoretical foundations of exogenous and endogenous growth models. The importance of growth for nations and discussion of some (well-known) growth theories together with the role of innovation, human capital and environment will therefore be primary focuses of this course.

Learning objective:
Students shall be given the ability to understand, analyze and evaluate selected models of endogenous growth theory.

Course content:
- Intertemporal consumption decision
- Growth models with exogenous saving rates: Solow
- Growth models with endogenous saving rates: Ramsey
- Growth and environmental resources
- Basic models of endogenous growth
- Human capital and economic growth
- Modelling of technological progress
- Diversity Models
- Schumpeterian growth
- Directional technological progress
- Diffusion of technologies

Recommendations:
Basic knowledge of micro- and macroeconomics is assumed, as taught in the courses Economics I [2600012], and Economics II [2600014]. In addition, an interest in quantitative-mathematical modeling is required.

Workload:
The total workload for this course is approximately 135.0 hours. For further information see German version.

Exam description:
The assessment consists of a written exam (60 min) according to Section 4(2), 1 of the examination regulation. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

Students will be given the opportunity of writing and presenting a short paper during the lecture time to achieve a bonus on the exam grade. If the mandatory credit point exam is passed, the awarded bonus points will be added to the regular exam points. A deterioration is not possible by definition, and a grade does not necessarily improve, but is very likely to (not every additional point improves the total number of points, since a grade can not become better than 1). The voluntary elaboration of such a paper can not countervail a fail in the exam.

Literature
Auszug:
## 4.128 Course: Harmonic Analysis [T-MATH-111289]

**Responsible:** Prof. Dr. Dorothee Frey  
apl. Prof. Dr. Peer Kunstmann  
Prof. Dr. Roland Schnaubelt  
Dr. rer. nat. Patrick Tolksdorf

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105324 - Harmonic Analysis

<table>
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<tr>
<td>Oral examination</td>
<td>8</td>
<td>Grade to a third</td>
<td>1</td>
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</table>
### 4.129 Course: Harmonic Analysis 2 [T-MATH-113103]

**Responsible:** Prof. Dr. Dorothee Frey  
apl. Prof. Dr. Peer Kunstmann  
Dr. rer. nat. Patrick Tolksdorf

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-106486 - Harmonic Analysis 2

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<table>
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<tr>
<th>Exams</th>
<th>Credits</th>
<th>Exam Code</th>
<th>Exam Name</th>
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<tbody>
<tr>
<td>ST 2024</td>
<td>7700115</td>
<td>Harmonic Analysis 2</td>
<td>Kunstmann</td>
</tr>
</tbody>
</table>

**Competence Certificate**

oral examination of ca. 30 minutes.

**Prerequisites**

none

**Recommendation**

The following modules are strongly recommended: "Harmonic Analysis", "Functional Analysis".
4.130 Course: Heat Economy [T-WIWI-102695]

**Responsible:** Prof. Dr. Wolf Fichtner

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101452 - Energy Economics and Technology

<table>
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<th>Grading scale</th>
<th>Recurrence</th>
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<th>Heat Economy</th>
<th>2 SWS</th>
<th>Lecture / 🗣</th>
<th>Fichtner</th>
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**Exams**

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<th>Fichtner</th>
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Legend: 🖥 Online, ☰ Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

The assessment consists of a written (60 minutes) or oral exam (30 minutes) (following §4(2) of the examination regulation). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

**Prerequisites**

None.

**Recommendation**

None

**Annotation**

See German version.

Below you will find excerpts from events related to this course:

**Heat Economy**

2581001, SS 2024, 2 SWS, Language: German, Open in study portal

**Organizational issues**

Block, Seminarraum Standort West - siehe Institutsaushang
4.131 Course: Homotopy Theory [T-MATH-105933]

**Responsible:** Prof. Dr. Roman Sauer

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102959 - Homotopy Theory

<table>
<thead>
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<tr>
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**Responsible:** Prof. Dr.-Ing. Tamim Asfour  
Hon.-Prof. Dr. Uwe Spetzger  

**Organisation:** KIT Department of Informatics  

**Part of:** M-INFO-100725 - Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy  

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<td>Each term</td>
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**Type:** Written examination  
**Credits:** 3  
**Grading scale:** Grade to a third  
**Recurrence:** Each term  
**Version:** 2

### Events

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<td>2 SWS</td>
<td>Lecture / 📚</td>
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### Exams

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<td>Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy</td>
<td>Spetzger</td>
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4.133 Course: Human Factors in Autonomous Driving [T-WIWI-113059]

Responsible: Prof. Dr. Alexey Vinel
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

<table>
<thead>
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<td>Lecture / 🔄</td>
<td>4,5</td>
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<td>Each winter term</td>
<td>Vinel, Bied, Schrapel</td>
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<td>WT 24/25</td>
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<td>Vinel, Bied, Schrapel</td>
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Exams

| ST 2024 | 7900360 | Human Factors in Autonomous Driving       |      |                     |         |               |                     | Vinel               |

Legend: 🖥 Online, 🔄 Blended (On-Site/Online), 🗳 On-Site, ✗ Cancelled

Competence Certificate

The assessment of this course is a written examination (60 min) or an oral exam (20 min). The exam takes place every semester and can be repeated at every regular examination date.

**Responsible:** Prof. Dr. Melanie Volkamer  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics

<table>
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<td>Grade to a third</td>
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**Competence Certificate**
The assessment of this course is a written examination (60 min) according to §4(2), 1 of the examination regulation or an oral exam (30 min) following §4, Abs. 2, 2 of the examination regulation. Only those who have successfully participated in the exercises and the lecture will be admitted to the examination.

**Prerequisites**
Both need to be done:
- Pass Quiz on Paper for Graphical Passwords
- Presentation of Results Exercise 2

+ 9 of the following 11 need to be done:
- Submit ILIAS certificate until Oct 24
- Pass Quiz on InfoSec Lecture
- Active participation exercise 1 Part 1 - Evaluation and analyses methods
- Pass Quiz Paper Discussion 1 - User Behaviour and motivation theories
- Active participation exercise 1 Part 2
- Pass Quiz Paper Discussion 2 - User Behaviour and motivation theories
- Pass Quiz Paper Discussion 3 - Security Awareness
- Active participation exercise 1 Part 3
- Pass Quiz Paper Discussion 4 - Graphical Authentication
- Pass Quiz Paper Discussion 5 - Shoulder Surfing Authentication
- Active participation exercise 2

**Recommendation**
The prior attendance of the lecture "Information Security" is strongly recommended.

**Annotation**
The lecture will not be offered in winter semester 2020/21.  
Some lectures are in English, some in German.

Responsible: Prof. Dr.-Ing. Jürgen Beyerer  
Dr.-Ing. Florian van de Camp

Organisation: KIT Department of Informatics

Part of: M-INFO-100824 - Human-Machine-Interaction in Anthropomatics: Basics

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<th>Recurrence</th>
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<td>Each winter term</td>
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Events

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<th>Lecturer</th>
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<td>Human-Machine-Interaction in Anthropomatics: Basics</td>
<td>2 SWS</td>
<td>Lecture / 🧩</td>
<td>van de Camp</td>
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Exams

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<th>Event</th>
<th>Code</th>
<th>Type</th>
<th>Lecturer</th>
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Legend: Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled
4.136 Course: Incentives in Organizations [T-WIWI-105781]

**Responsible:** Prof. Dr. Petra Nieken  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101500 - Microeconomic Theory

<table>
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<td>2 SWS</td>
<td>Incentives in Organizations</td>
<td>Lecture / 🗣</td>
<td>Nieken</td>
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<td>ST 2024 2573004</td>
<td>2 SWS</td>
<td>Übung zu Incentives in Organizations</td>
<td>Practice / 🗣</td>
<td>Nieken, Mitarbeiter, Walther, Gorny</td>
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**Exams**

<table>
<thead>
<tr>
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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

The assessment of this course is a written examination (60 min). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date. In case of a small number of registrations, we might offer an oral exam instead of a written exam.

**Prerequisites**

None

**Recommendation**

Knowledge of microeconomics, game theory, and statistics is assumed.

**Below you will find excerpts from events related to this course:**

**Incentives in Organizations**

2573003, SS 2024, 2 SWS, Language: English, [Open in study portal](#)
Content
The students acquire profound knowledge about the design and the impact of different incentive and compensation systems. Topics covered are, for instance, performance based compensation, team work, intrinsic motivation, multitasking, and subjective performance evaluations. We will use microeconomic or behavioral models as well as empirical data to analyze incentive systems. We will investigate several widely used compensation schemes and their relationship with corporate strategy. Students will learn to develop practical implications which are based on the acquired knowledge of this course.

Aim
The student
- develops a strategic understanding about incentives systems and how they work.
- analyzes models from personnel economics.
- understands how econometric methods can be used to analyze performance and compensation data.
- knows incentive schemes that are used in companies and is able to evaluate them critically.
- can develop practical implications which are based on theoretical models and empirical data from companies.
- understands the challenges of managing incentive and compensation systems and their relationship with corporate strategy.

Workload
The total workload for this course is: approximately 135 hours.
Lecture: 32 hours
Preparation of lecture: 52 hours
Exam preparation: 51 hours

Literature
Slides, Additional case studies and research papers will be announced in the lecture.
Literature (complementary):
Behavioral Game Theory, Camerer, Russel Sage Foundation, 2003
Introduction to Econometrics, Wooldridge, Andover, 2014
Econometric Analysis of Cross Section and Panel Data, Wooldridge, MIT Press, 2010
4.137 Course: In-depth Module - Doing Culture - Self Assignment BAK [T-ZAK-112655]

**Responsible:** Dr. Christine Mielke
Christine Myglas

**Organisation:**
Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

<table>
<thead>
<tr>
<th>Type</th>
<th>Credits</th>
<th>Grading scale</th>
<th>Version</th>
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<tbody>
<tr>
<td>Examination of another type</td>
<td>3</td>
<td>Grade to a third</td>
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**Competence Certificate**

At least two presentations must be given: An examination of another kind according to § 5 section 3 (3) in the form of a presentation in one of the chosen courses (3 ECT).

In a third seminar, either (a) a presentation is held (preliminary study achievement) which remains not graded and a topic-related term paper is submitted or (b) a written exam is taken.

The three courses can be selected individually from the 5 thematic blocks or – in exceptional cases and according to the agreement with the responsible lecturer – all three courses can be selected from one block in the sense of a specialization. In addition, an oral examination is taken, which relates to the content of two of the chosen three courses.

**Prerequisites**

Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

**Self service assignment of supplementary studies**

This course can be used for self service assignment of grade acquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

**Annotation**

The content of the Basic Modul is helpful.
### 4.138 Course: In-depth Module - Global Cultures - Self Assignment BAK [T-ZAK-112658]

**Responsibility:** Dr. Christine Mielke  
Christine Myglas

**Organisation:**  
**Part of:** M-ZAK-106235 - Supplementary Studies on Culture and Society

<table>
<thead>
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<th>Type</th>
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<tr>
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**Competence Certificate**
At least two presentations must be given: An examination of another kind according to § 5 section 3 (3) in the form of a presentation in one of the chosen courses (3 ECT).
In a third seminar, either (a) a presentation is held (preliminary study achievement) which remains not graded and a topic-related term paper is submitted or (b) a written exam is taken.
The three courses can be selected individually from the 5 thematic blocks or – in exceptional cases and according to the agreement with the responsible lecturer – all three courses can be selected from one block in the sense of a specialization.
In addition, an oral examination is taken, which relates to the content of two of the chosen three courses.

**Prerequisites**
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

**Self service assignment of supplementary studies**
This course can be used for self service assignment of grade acquired from the following study providers:
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

**Annotation**
The content of the Basic Module is helpful.
4.139 Course: In-depth Module - Media & Aesthetics - Self Assignment BAK [T-ZAK-112656]

**Responsible:** Dr. Christine Mielke
Christine Myglas

**Organisation:**
Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

<table>
<thead>
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<th>Type</th>
<th>Credits</th>
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**Competence Certificate**
At least two presentations must be given: An examination of another kind according to § 5 section 3 (3) in the form of a presentation in one of the chosen courses (3 ECT).
In a third seminar, either (a) a presentation is held (preliminary study achievement) which remains not graded and a topic-related term paper is submitted or (b) a written exam is taken.
The three courses can be selected individually from the 5 thematic blocks or – in exceptional cases and according to the agreement with the responsible lecturer – all three courses can be selected from one block in the sense of a specialization.
In addition, an oral examination is taken, which relates to the content of two of the chosen three courses.

**Prerequisites**
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

**Self service assignment of supplementary studies**
This course can be used for self service assignment of grade acquired from the following study providers:
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

**Annotation**
The content of the Basic Modul is helpful.
4.140 Course: In-depth Module - Spheres of Life - Self Assignment BAK [T-ZAK-112657]

**Responsible:** Dr. Christine Mielke
Christine Myglas

**Organisation:**
Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

<table>
<thead>
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**Competence Certificate**
At least two presentations must be given: An examination of another kind according to § 5 section 3 (3) in the form of a presentation in one of the chosen courses (3 ECT).
In a third seminar, either (a) a presentation is held (preliminary study achievement) which remains not graded and a topic-related term paper is submitted or (b) a written exam is taken.
The three courses can be selected individually from the 5 thematic blocks or – in exceptional cases and according to the agreement with the responsible lecturer – all three courses can be selected from one block in the sense of a specialization.
In addition, an oral examination is taken, which relates to the content of two of the chosen three courses.

**Prerequisites**
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

**Self service assignment of supplementary studies**
This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

**Annotation**
The content of the Basic Modul is helpful.
### 4.141 Course: In-depth Module - Technology & Responsibility - Self Assignment BAK [T-ZAK-112654]

**Responsible:** Dr. Christine Mielke
Christine Myglas

**Organisation:**
**Part of:** M-ZAK-106235 - Supplementary Studies on Culture and Society

<table>
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<th>Type</th>
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<td>Grade to a third</td>
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**Competence Certificate**
At least two presentations must be given: An examination of another kind according to § 5 section 3 (3) in the form of a presentation in one of the chosen courses (3 ECT).

In a third seminar, either (a) a presentation is held (preliminary study achievement) which remains not graded and a topic-related term paper is submitted or (b) a written exam is taken.

The three courses can be selected individually from the 5 thematic blocks or – in exceptional cases and according to the agreement with the responsible lecturer – all three courses can be selected from one block in the sense of a specialization.

In addition, an oral examination is taken, which relates to the content of two of the chosen three courses.

**Prerequisites**
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

**Self service assignment of supplementary stdues**
This course can be used for self service assignment of grade acquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

**Annotation**
The content of the Basic Modul is helpful.
# 4.142 Course: Information and Automation Technology [T-ETIT-112878]

**Responsible:** Prof. Dr.-Ing. Mike Barth  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-106336 - Information and Automation Technology

<table>
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<th>Type</th>
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<td>Barth</td>
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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**
The success check takes the form of a written exam lasting 120 minutes.

**Prerequisites**
none
4.143 Course: Information and Automation Technology - Lab Course [T-ETIT-112879]

**Responsible:** Prof. Dr.-Ing. Eric Sax

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-ETIT-106336 - Information and Automation Technology

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<th>Practical course / 🧩</th>
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**Exams**

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<th>7311653</th>
<th>Information Technology I - Practical course</th>
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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🔴 On-Site, ✗ Cancelled

**Competence Certificate**

A performance check in the form of a coursework consisting of project documentation and checking the source code as part of the internship course

**Prerequisites**

none
4.144 Course: Information Security [T-INFO-112195]

**Responsible:** Prof. Dr. Jörn Müller-Quade

**Organisation:** KIT Department of Informatics

**Part of:** M-INFO-106015 - Information Security

<table>
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<td>Each summer term</td>
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**Events**

| ST 2024 | 2400199 | Informationssicherheit | 3 SWS | Lecture / Practice (Müller-Quade, Strufe, Hartenstein, Wressnegger) |

**Exams**

| ST 2024 | 7500028 | Information Security   | Müller-Quade, Wressnegger, Strufe |
| ST 2024 | 7500302 | Information Security   | Strufe, Hartenstein |

**Modeled Conditions**

The following conditions have to be fulfilled:

1. The course T-INFO-101371 - Security must not have been started.
4.145 Course: Information Service Engineering [T-WIWI-106423]

Responsible: Prof. Dr. Harald Sack
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

<table>
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Events

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<td>2511606</td>
<td>Information Service Engineering</td>
<td>2 SWS</td>
<td>Lecture</td>
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<td>ST 2024</td>
<td>2511607</td>
<td>Exercises to Information Service Engineering</td>
<td>1 SWS</td>
<td>Practice</td>
<td>Sack</td>
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Exams

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<td>Information Service Engineering (Registration until 15 July 2024)</td>
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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

Competence Certificate

The assessment of this course is a written examination (60 min) according to §4(2), 1 of the examination regulation or an oral exam (20 min) following §4, Abs. 2, 2 of the examination regulation.

The exam takes place every semester and can be repeated at every regular examination date.

Prerequisites

None

Below you will find excerpts from events related to this course:

Information Service Engineering

Code: 2511606, SS 2024, 2 SWS, Language: English, [Open in study portal](#)
Content
- The Art of Understanding
  - From Numbers to Insights
  - Data, Information, and Knowledge
  - Natural Language
  - What is Successful Communication?
  - The Art of Understanding

- Natural Language Processing
  - NLP and Basic Linguistic Knowledge
  - NLP Applications, Techniques and Challenges
  - How to evaluate an NLP Experiment?
  - Tokenization and Word Normalisation
  - Statistical Language Models (N-Gram Model)
  - Naive Bayes Text Classification
  - Distributional Semantics and Word Vectors

- Knowledge Graphs
  - Knowledge Representations and Ontologies
  - Resource Description Framework (RDF)
  - Modeling with RDFS
  - Querying RDF(S) with SPARQL
  - Popular Knowledge Graphs - Wikidata and DBpedia
  - Ontologies with the Web Ontology Language (OWL)
  - Linked Data Quality Assurance with SHACL
  - From Linked Data to Knowledge Graphs

- Basic Machine Learning
  - Machine Learning Fundamentals
  - Evaluation and Generalization Problems
  - Linear Regression
  - Decision Trees
  - Unsupervised Learning
  - Neural Networks and Deep Learning
  - Word Embeddings
  - Knowledge Graph Embeddings

- ISE Applications
  - Knowledge Graph Completion
  - Knowledge Graphs and Large Language Models
  - Semantic and Exploratory Search
  - Semantic Recommender Systems

Learning objectives:
- The students know the fundamentals and measures of information theory and are able to apply those in the context of Information Service Engineering.
- The students have basic skills of natural language processing and are enabled to apply natural language processing technology to solve and evaluate simple text analysis tasks.
- The students have fundamental skills of knowledge representation with ontologies as well as basic knowledge of Semantic Web and Linked Data technologies. The students are able to apply these skills for simple representation and analysis tasks.
- The students have fundamental skills of information retrieval and are enabled to conduct and to evaluate simple information retrieval tasks.
- The students apply their skills of natural language processing, Linked Data engineering, and Information Retrieval to conduct and evaluate simple knowledge mining tasks.
- The students know the fundamentals of recommender systems as well as of semantic and exploratory search.

Literature
### 4.146 Course: Integral Equations [T-MATH-105834]

**Responsible:**
- PD Dr. Tilo Arens
- Prof. Dr. Roland Griesmaier
- PD Dr. Frank Hettlich

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102874 - Integral Equations

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<td>Übungen zu 0160500 (Integralgleichungen)</td>
<td>2 SWS</td>
<td>Practice</td>
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<td>7700146</td>
<td>Integral Equations</td>
<td>Hettlich</td>
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4.147 Course: International Finance [T-WIWI-102646]

**Responsible:** Prof. Dr. Marliese Uhrig-Homburg

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101480 - Finance 3
- M-WIWI-101483 - Finance 2

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**Events**

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<td>International Finance</td>
<td>2</td>
<td>Lecture / 🗣</td>
<td>Walter, Uhrig-Homburg</td>
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**Exams**

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<td>International Finance</td>
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<td>Uhrig-Homburg</td>
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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

Depending on further pandemic developments, the examination will be offered either as a 60-minute written examination (written examination according to SPO § 4 Abs. 2, Pkt. 1) or as an open-book examination (alternative exam assessment according to SPO § 4 Abs. 2, Pkt. 3).

**Prerequisites**

None

**Recommendation**

None

**Annotation**

The course is offered as a 14-day or block course.

---

**Below you will find excerpts from events related to this course:**

**International Finance**

2530570, SS 2024, 2 SWS, Language: German, [Open in study portal](#)

**Lecture (V)**

On-Site

**Organizational issues**

Kickoff am Mittwoch, 24.04.24, 15:45 - 19:00 Uhr im Raum 320 im Geb. 09.21 (Blücherstr. 17). Die Veranstaltung wird samstags als Blockveranstaltung angeboten, nach dem Kickoff nach Absprache.

**Literature**

**Weiterführende Literatur:**

4.148 Course: Internet Seminar for Evolution Equations [T-MATH-105890]

**Responsible:**
- Prof. Dr. Dorothee Frey
- apl. Prof. Dr. Peer Kunstmann
- Prof. Dr. Roland Schnaubelt
- Dr. rer. nat. Patrick Tolksdorf

**Organisation:**
KIT Department of Mathematics

**Part of:**
M-MATH-102918 - Internet Seminar for Evolution Equations

---

**Type**
- Written examination

**Credits**
- 8

**Grading scale**
- Grade to a third

**Version**
- 1

---

**Events**

| WT 24/25 | 0105000 | Internetseminar für Evolutionsgleichungen | 2 SWS | Lecture / 🗣️ | Schnaubelt, Kunstmann, Frey, Tolksdorf |

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣️ On-Site, ✗ Cancelled

**Competence Certificate**
oral examination of ca. 30 minutes

**Prerequisites**
none
4.149 Course: Introduction into Particulate Flows [T-MATH-105911]

**Responsible:** Prof. Dr. Willy Dörfler

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102943 - Introduction into Particulate Flows

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**Prerequisites**

none
4.150 Course: Introduction to Aperiodic Order [T-MATH-110811]

**Responsible:** Prof. Dr. Tobias Hartnick

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105331 - Introduction to Aperiodic Order

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**Prerequisites**
none
### 4.151 Course: Introduction to Artificial Intelligence [T-INFO-112194]

**Responsible:** TT-Prof. Dr. Pascal Friederich  
Prof. Dr. Gerhard Neumann

**Organisation:** KIT Department of Informatics  
**Part of:** M-INFO-106014 - Introduction to Artificial Intelligence

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**Events**

| WT 24/25 | 2400158 | Introduction to Artificial Intelligence | 3 SWS | Lecture / Practice ( / 👤) | Neumann, Friederich, Schäfer |

**Exams**

| ST 2024 | 7500058 | Introduction to Artificial Intelligence | Neumann, Friederich |

Legend: 🖥 Online, ⛓ Blended (On-Site/Online), 👤 On-Site, ✗ Cancelled
4.152 Course: Introduction to Convex Integration [T-MATH-112119]

**Responsible:** Dr. Christian Zillinger

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105964 - Introduction to Convex Integration

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<td>Irregular</td>
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**Competence Certificate**
oral examination of approx. 30 minutes

**Prerequisites**
none

**Recommendation**
The courses “Classical Methods for Partial Differential Equations” and “Functional Analysis” are recommended.
Course: Introduction to Dynamical Systems [T-MATH-113263]

Responsible: Dr. Björn de Rijk  
Prof. Dr. Wolfgang Reichel

Organisation: KIT Department of Mathematics

Part of: M-MATH-106591 - Introduction to Dynamical Systems

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Competence Certificate
oral exam of ca. 30 min

Prerequisites
none
4.154 Course: Introduction to Fluid Dynamics [T-MATH-111297]

**Responsible:** Prof. Dr. Wolfgang Reichel

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105650 - Introduction to Fluid Dynamics

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**Prerequisites**
none
### 4.155 Course: Introduction to Fluid Mechanics [T-MATH-112927]

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<td>1 terms</td>
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**Competence Certificate**
The module examination takes the form of an oral examination of approx. 25 minutes.

**Prerequisites**
none

**Recommendation**
The module *Functional Analysis* is strongly recommended.
4.156 Course: Introduction to Geometric Measure Theory [T-MATH-105918]

Responsible: PD Dr. Steffen Winter
Organisation: KIT Department of Mathematics
Part of: M-MATH-102949 - Introduction to Geometric Measure Theory

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Prerequisites
none
4.157 Course: Introduction to Homogeneous Dynamics [T-MATH-110323]

**Responsible:** Prof. Dr. Tobias Hartnick  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-105101 - Introduction to Homogeneous Dynamics

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**Prerequisites**  
none
**4.158 Course: Introduction to Kinetic Equations [T-MATH-111721]**

**Responsible:** Dr. Christian Zillinger  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-105837 - Introduction to Kinetic Equations

<table>
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<td>1 terms</td>
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**Competence Certificate**  
oral examination of circa 30 minutes

**Prerequisites**  
none

**Recommendation**  
The course "Classical Methods for Partial Differential Equations" should be studied beforehand.
Below you will find excerpts from events related to this course:

### Introduction to Kinetic Theory

<table>
<thead>
<tr>
<th>Events</th>
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<td>Grade to a third</td>
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<td>Tutorial for 0155450 (Introduction to Kinetic Theory)</td>
<td>Practice</td>
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Legend: 📱 Online, 🤖 Blended (On-Site/Online), 📺 On-Site, ✗ Cancelled

### Prerequisites

none

### Content

Kinetic descriptions play an important role in a variety of physical, biological, and even social applications, for instance, in the description of gases, radiations, bacteria or financial markets. Typically, these systems are described locally not by a finite set of variables but instead by a probability density describing the distribution of a microscopic state. Its evolution is typically given by an integro-differential equation. Unfortunately, the large phase space associated with the kinetic description has made simulations impractical in most settings in the past. However, recent advances in computer resources, reduced-order modeling and numerical algorithms are making accurate approximations of kinetic models more tractable, and this trend is expected to continue in the future. On the theoretical mathematical side, two rather recent Fields medals (Pierre-Louis Lions 1994, Cédric Villani 2010) also indicate the continuing interest in this field, which was already the subject of Hilbert’s sixth out of the 23 problems presented at the World Congress of Mathematicians in 1900.

This course gives an introduction to kinetic theory. Our purpose is to discuss the mathematical passage from a microscopic description of a system of particles, via a probabilistic description to a macroscopic view. This is done in a complete way for the linear case of particles that are interacting with a background medium. The nonlinear case of pairwise interacting particles is treated on a more phenomenological level.

An extremely broad range of mathematical techniques is used in this course. Besides mathematical modeling, we make use of statistics and probability theory, ordinary differential equations, hyperbolic partial differential equations, integral equations (and thus functional analysis) and infinite-dimensional optimization. Among the astonishing discoveries of kinetic theory are the statistical interpretation of the Second Law of Thermodynamics, induced by the Boltzmann-Grad limit, and the result that the macroscopic equations describing fluid motion (namely the Euler and Navier-Stokes equations) can be inferred from abstract geometrical properties of integral scattering operators.

### Organizational issues

The course will be offered in flipped classroom format. Flipped classroom means that the lectures will be made available as videos. We will regularly meet for tutorials and discussion sessions.
4.160 Course: Introduction to Microlocal Analysis [T-MATH-111722]

Responsible: TT-Prof. Dr. Xian Liao
Organisation: KIT Department of Mathematics
Part of: M-MATH-105838 - Introduction to Microlocal Analysis

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Competence Certificate
oral examination of circa 30 minutes

Prerequisites
none

Recommendation
The courses "Classical Methods for Partial Differential Equations" and "Functional Analysis" should be studied beforehand.
# Course: Introduction to Python [T-MATH-106119]

**Responsible:** Dr. Daniel Weiß  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-103053 - Key Competences

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<td>Einführung in Python</td>
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<td>Introduction to Python</td>
<td>Weiβ</td>
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Course: Introduction to Python - Programming Project [T-MATH-111851]

**Responsible:** Dr. Daniel Weiß  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-103053 - Key Competences

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<td>Each summer term</td>
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4.163 Course: Introduction to Scientific Computing [T-MATH-105837]

**Responsible:**
- Prof. Dr. Willy Dörfler
- Prof. Dr. Marlis Hochbruck
- Prof. Dr. Tobias Jahnke
- Prof. Dr. Andreas Rieder
- Prof. Dr. Christian Wieners

**Organisation:**
KIT Department of Mathematics

**Part of:**
M-MATH-102889 - Introduction to Scientific Computing

**Type**
- Oral examination

**Credits**
- 8

**Grading scale**
- Grade to a third

**Version**
- 2

**Events**

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<td>0165000</td>
<td>Einführung in das Wissenschaftliche Rechnen</td>
<td>3</td>
<td>Lecture</td>
<td>Wieners</td>
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<td>0165010</td>
<td>Praktikum zu 0165000 (Einführung in das Wissenschaftliche Rechnen)</td>
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<td>Practical course</td>
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**Exams**

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<tr>
<td></td>
<td>7731415</td>
<td>Introduction to Scientific Computing</td>
<td>Wieners</td>
</tr>
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</table>
4.164 Course: Introduction to Stochastic Differential Equations [T-MATH-112234]

Responsible: Josef Janák
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: M-MATH-106045 - Introduction to Stochastic Differential Equations

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<td>4</td>
<td>Grade to a third</td>
<td>Irregular</td>
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</table>

Competence Certificate
The module will be completed with an oral exam (approx. 30 min).

Prerequisites
none

Recommendation
The contents of the module "Probability Theory" are strongly recommended. The module "Continuous Time Finance" is recommended.
4.165 Course: Introduction to Stochastic Optimization [T-WIWI-106546]

**Responsible:** Prof. Dr. Steffen Rebennack

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101414 - Methodical Foundations of OR
- M-WIWI-102832 - Operations Research in Supply Chain Management

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**Events**

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<td>Lecture / 🖥</td>
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<td>Übung zur Einführung in die Stochastische Optimierung</td>
<td>1 SWS</td>
<td>Practice / 🗣</td>
<td>Rebennack, Kandora</td>
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<td>Rechnerübung zur Einführung in die Stochastische Optimierung</td>
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<td>Others (sons)</td>
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**Exams**

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<td>7900242</td>
<td>Introduction to Stochastic Optimization</td>
<td>Rebennack</td>
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Legend: 🖥 Online, ☑ Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**
The assessment consists of a written exam (60 minutes). The exam takes place in every semester.

**Prerequisites**
None.
4.166 Course: Inverse Problems [T-MATH-105835]

**Responsible:**
- PD Dr. Tilo Arens
- Prof. Dr. Roland Griesmaier
- PD Dr. Frank Hettlich
- Prof. Dr. Andreas Rieder

**Organisation:**
- KIT Department of Mathematics

**Part of:**
- M-MATH-102890 - Inverse Problems

**Type:** Oral examination
**Credits:** 8
**Grading scale:** Grade to a third
**Version:** 1

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<td>0105110</td>
<td>Tutorial for 0105100 (Inverse Problems)</td>
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<td>Practice / 🗣️</td>
<td>Rieder</td>
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</table>

Legend: 🖥 Online, 📦 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled
### 4.167 Course: IT Security [T/INFO-112818]

**Responsible:**
- Prof. Dr. Hannes Hartenstein
- Prof. Dr. Jörn Müller-Quade
- Prof. Dr. Thorsten Strufe
- TT-Prof. Dr. Christian Wressnegger

**Organisation:**
- KIT Department of Informatics

**Part of:**
- M/INFO-106315 - IT Security

<table>
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<td>Each winter term</td>
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**Events**

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<td>IT Security</td>
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<td>Muller-Quade, Wressnegger</td>
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**Legend:**
- Online
- Blended (On-Site/Online)
- On-Site
- Cancelled

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**Competence Certificate**

The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 90 minutes.

**Prerequisites**

None.

**Recommendation**

Students should be familiar with the content of the compulsory lecture "Informationssicherheit".
4.168 Course: Key Moments in Geometry [T-MATH-108401]

Responsibility: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-104057 - Key Moments in Geometry

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Prerequisites
none
4.169 Course: Knowledge Discovery [T-WIWI-102666]

**Responsible:** Dr.-Ing. Tobias Käfer

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101472 - Informatics

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<th>SWS</th>
<th>Type</th>
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<td>WT 24/25</td>
<td>2511303</td>
<td></td>
<td>Knowledge Discovery, Graph Neural Networks, and Language Models</td>
<td>3</td>
<td>Lecture / Practice ( / 🧩)</td>
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</table>

Käfer, Shao

**Competence Certificate**

The examination will be offered for the last time in the winter semester 2024/2025. The last examination opportunity (only for repeaters) will take place in the summer semester 2025.

Instead of a final written exam, the record of achievement will be measured via project work, exercise assignments, and presentations. Specifically, the students will collaborate in groups of 3-4 to complete a comprehensive project which included a project proposal, mid-term report, and final report, cumulatively contributing 50% to their overall grade. Additionally, students will showcase their understanding of course material through the timely submission of three short assignments (totaling 25% of their grade). During the course, students will showcase their proficiency in public speaking and critical analysis by delivering engaging class presentations and discussions (25% of the grade).

**Prerequisites**

None

**Annotation**

The course will no longer be offered from winter semester 2024/2025.

Below you will find excerpts from events related to this course:

**Knowledge Discovery, Graph Neural Networks, and Language Models**

2511303, WS 24/25, 3 SWS, Language: English, [Open in study portal](#)
Content

The lecture provides a comprehensive overview of various approaches in machine learning and data mining for knowledge extraction. It explores multiple fields, including machine learning, natural language processing, and knowledge representation. The main focus is on discovering patterns and regularities in extensive data sets, particularly unstructured text found in news articles, publications, and social media. This process is known as knowledge discovery. The lecture delves into specific techniques, methods, challenges, as well as current and future research topics within this field.

One part of the lecture is dedicated to understanding large language models (LLMs), such as ChatGPT, by exploring their underlying principles, training methods, and applications. Additionally, the lecture dives into graph representation learning, which involves extracting meaningful representations from graph data. It covers the mathematical foundations of graph and geometric deep learning, highlighting the latest applications in areas like explainable recommender systems.

Moreover, the lecture highlights the integration of knowledge graphs with large language models, known as neurosymbolic AI. This integration aims to combine structured and unstructured data to enhance knowledge extraction and representation.

The content of the lecture encompasses the entire machine learning and data mining process. It covers topics on supervised and unsupervised learning techniques, as well as empirical evaluation. Various learning methods are explored, ranging from classical approaches like decision trees, support vector machines, and neural networks to more recent advancements such as graph neural networks.

Learning objectives:

Students

- know fundamentals of Machine Learning, Data Mining and Knowledge Discovery.
- are able to design, train and evaluate adaptive systems.
- conduct Knowledge Discovery projects in regards to algorithms, representations and applications.

Workload:

- The total workload for this course is approximately 135 hours
- Time of presentness: 45 hours
- Time of preparation and postprocessing: 60 hours
- Exam and exam preparation: 30 hours

Literature

- M. Berhold, D. Hand (eds). Intelligent Data Analysis - An Introduction. 2003
- P. Tan, M. Steinbach, V. Kumar: Introduction to Data Mining, 2005, Addison Wesley
4.170 Course: L2-Invariants [T-MATH-105924]

**Responsible:** Dr. Holger Kammeyer  
Prof. Dr. Roman Sauer  

**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102952 - L2-Invariants  

**Type**  Oral examination  
**Credits**  5  
**Grading scale**  Grade to a third  
**Version**  1  

**Prerequisites**  
none
### 4.171 Course: Large-scale Optimization [T-WWI-106549]

**Responsible:** Prof. Dr. Steffen Rebennack  
**Organisation:** KIT Department of Economics and Management  
**Part of:**  
- M-WIWI-101473 - Mathematical Programming  
- M-WIWI-102832 - Operations Research in Supply Chain Management

<table>
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#### Events

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<td>2 SWS</td>
<td>Lecture / Online</td>
<td>Rebennack</td>
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<td>ST 2024</td>
<td>Übung zu Large-Scale Optimization</td>
<td>1 SWS</td>
<td>Practice / On-Site</td>
<td>Bijiga, Rebennack</td>
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<td>Rechnerübung zu Large-scale Optimization</td>
<td>2 SWS</td>
<td>Others (son)</td>
<td>Rebennack, Bijiga</td>
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<th>Type</th>
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<td>Rebennack</td>
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<td>WT 24/25</td>
<td>Large-scale Optimization</td>
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<td>Rebennack</td>
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</table>

#### Competence Certificate

The assessment consists of a written exam (60 minutes). The exam takes place in every semester.

#### Prerequisites

None.
### 4.172 Course: Lie Groups and Lie Algebras [T-MATH-108799]

| **Responsible:** | Prof. Dr. Tobias Hartnick |
| **Organisation:** | KIT Department of Mathematics |
| **Part of:** | M-MATH-104261 - Lie Groups and Lie Algebras |

| **Type** | Oral examination |
| **Credits** | 8 |
| **Grading scale** | Grade to a third |
| **Recurrence** | Irregular |
| **Version** | 1 |
## 4.173 Course: Lie-Algebras (Linear Algebra 3) [T-MATH-111723]

**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-105839 - Lie-Algebras (Linear Algebra 3)

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**Prerequisites**

none
4.174 Course: Linear Electronic Networks [T-ETIT-101917]

**Responsible:** Prof. Dr. Olaf Dössel

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-ETIT-101845 - Linear Electronic Networks

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**Events**

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<td>Linear Electric Circuits</td>
<td>Lecture / 🗣</td>
<td>Kempf, Jelonnek</td>
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<td>WT 24/25</td>
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<td>1 SWS</td>
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**Exams**

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<td>WT 24/25</td>
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</table>

Legend: 🖥 Online, ☑ Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

The content of the course Linear Electrical Networks (7 CP) will be checked in a written exam lasting 120 minutes. If the exam is passed, students can receive a grade bonus of up to 0.4 grade points if two project tasks have been successfully completed during the semester. The processing of the project tasks is evidenced by the submission of documentation or the project code.

**Prerequisites**

none
4.175 Course: Localization of Mobile Agents [T-INFO-101377]

**Responsible:** Prof. Dr.-Ing. Uwe Hanebeck  
**Organisation:** KIT Department of Informatics  
**Part of:** M-INFO-100840 - Localization of Mobile Agents

<table>
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**Events**

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<td>3 SWS</td>
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<td>Each summer term</td>
<td>Hanebeck, Frisch</td>
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**Exams**

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<th>Title</th>
<th>Instructor</th>
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</table>

**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), ⌛ On-Site, ✕ Cancelled

**Below you will find excerpts from events related to this course:**

### Content

This module provides a systematic introduction into the topic of localization methods. In order to facilitate understanding, the module is divided into four main topics. Dead reckoning treats the instantaneous determination of a vehicle's position based on dynamic parameters like velocity or steering angle. Localization with the help of measurements of known landmarks is part of static localization. In addition to the closed-form solutions for particular measurements (distances and angles), the least squares method for fusion arbitrary measurements is also introduced. Dynamic localization treats the combination of dead reckoning and static localization. The central part of the lecture is the derivation of the Kalman filter, which has been successfully applied in several practical applications. Finally, simultaneous localization and mapping (SLAM) is introduced, which allows localization in case of (partly) unknown landmark positions.

### Organizational issues

Prüfungsterminvorschläge und das Verfahren dazu sind auf der Webseite der Vorlesung zu finden.

### Literature

Grundlegende Kenntnisse der linearen Algebra und Stochastik sind hilfreich.
4.176 Course: Machine Learning 1 - Basic Methods [T-WIWI-106340]

Responsible: Prof. Dr.-Ing. Johann Marius Zöllner
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

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Events

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<td>Lecture / 📚</td>
<td>Machine Learning 1 - Fundamental Methods</td>
<td>2 SWS</td>
<td>Zöllner</td>
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<td>WT 24/25</td>
<td>2511501</td>
<td>Practice / 📚</td>
<td>Exercises to Machine Learning 1 - Fundamental Methods</td>
<td>1 SWS</td>
<td>Zöllner Polley, Fechner, Daaboul</td>
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Exams

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<tbody>
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<td>79AIFB_ML1_C4</td>
<td>Machine Learning 1 - Basic Methods (Registration until 15 July 2024)</td>
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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 📚 On-Site, ✗ Cancelled

Competence Certificate

Depending on further pandemic developments, the exam will be offered either as an open-book exam, or as a written exam (60 min):

The exam takes place every semester and can be repeated at every regular examination date.

A grade bonus can be earned by successfully completing practice exercises. If the grade of the written exam is between 4.0 and 1.3, the bonus improves the grade by up to one grade level (0.3 or 0.4). Details will be announced in the lecture.

Prerequisites

None.

Below you will find excerpts from events related to this course:

Machine Learning 1 - Fundamental Methods

2511500, WS 24/25, 2 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

Content

The course prepares students for the rapidly evolving field of machine learning by providing a solid foundation, covering core concepts and techniques to get started in the field. Students delve into different methods in supervised, unsupervised, and reinforcement learning, as well as various model types, ranging from basic linear classifiers to more complex methods, such as deep neural networks. Topics include general learning theory, support vector machines, decision trees, neural network fundamentals, convolutional neural networks, recurrent neural networks, unsupervised learning, reinforcement learning, and Bayesian learning.

The course is accompanied by a corresponding exercise, where students gain hands-on experience by implementing and experimenting with different machine learning algorithms, helping them to apply machine learning algorithms on real world problems.

By the end of the course, students will have acquired a solid foundation in machine learning, enabling them to apply state-of-the-art algorithms to solve complex problems, contribute to research efforts, and explore advanced topics in the field.

Learning objectives:

- Students acquire knowledge of the fundamental methods in the field of machine learning.
- Students can classify, formally describe and evaluate methods of machine learning.
- Students can use their knowledge to select suitable models and methods for selected problems in the field of machine learning.
Literature
Die Foliensätze sind als PDF verfügbar

Weiterführende Literatur

- Machine Learning - Tom Mitchell
- Deep Learning - Ian Goodfellow, Yoshua Bengio, Aaron Courville
- Pattern Recognition and Machine Learning - Christopher M. Bishop
- Artificial Intelligence: A Modern Approach - Peter Norvig and Stuart J. Russell
- Reinforcement Learning: An Introduction - Richard S. Sutton and Andrew G. Barto

Weitere (spezifische) Literatur zu einzelnen Themen wird in der Vorlesung angegeben.
**4.177 Course: Machine Learning 2 – Advanced Methods [T-WIWI-106341]**

**Responsible:** Prof. Dr.-Ing. Johann Marius Zöllner  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics  

<table>
<thead>
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<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Version</th>
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<td>5</td>
<td>Grade to a third</td>
<td>Each summer term</td>
<td>4</td>
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</table>

**Events**

| ST 2024 | 2511502 | Machine Learning 2 - Advanced methods | 2 SWS | Lecture / 🗣 | Zöllner, Fechner, Polley |
| ST 2024 | 2511503 | Exercises for Machine Learning 2 - Advanced Methods | 1 SWS | Practice / 🗣 | Zöllner, Fechner, Polley |

**Exams**

| ST 2024 | 79AIFB_ML2_B1 | Machine Learning 2 – Advanced Methods (Registration until 15 July 2024) | Zöllner |

**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

Depending on further pandemic developments, the exam will be offered either as an open-book exam, or as a written exam (60 min).

The exam takes place every semester and can be repeated at every regular examination date.

**Prerequisites**

None.

Below you will find excerpts from events related to this course:

**Machine Learning 2 - Advanced methods**

2511502, SS 2024, 2 SWS, Language: German, Open in study portal

**Content**

The subject area of machine intelligence and, in particular, machine learning, taking into account real challenges of complex application domains, is a rapidly expanding field of knowledge and the subject of numerous research and development projects. The lecture "Machine Learning 2" deals with modern advanced methods of machine learning such as semi-supervised, self-supervised and active learning, deep neural networks (deep learning, CNNs, GANS, diffusion models, transformer, adversarial attacks) and hierarchical approaches, e.g. reinforcement learning. Another focus is the embedding and application of machine learning methods in real systems.

The lecture introduces the latest basic principles as well as extended basic structures and elucidates previously developed algorithms. The structure and the mode of operation of the methods and methods are presented and explained by means of some application scenarios, especially in the field of technical (sub) autonomous systems (vehicles, robotics, neurorobotics, image processing, etc.).

**Learning objectives:**

- Students understand extended concepts of machine learning and their possible applications.
- Students can classify, formally describe and evaluate methods of machine learning.
- In detail, methods of machine learning can be embedded and applied in complex decision and inference systems.
- Students can use their knowledge to select suitable models and methods of machine learning for existing problems in the field of machine intelligence.

**Recommendations:**

Attending the lecture Machine Learning 1 or a comparable lecture is very helpful in understanding this lecture.
Literature
Die Foliensätze sind als PDF verfügbar

Weiterführende Literatur
- Deep Learning - Ian Goodfellow
- Artificial Intelligence: A Modern Approach - Peter Norvig and Stuart J. Russell
- Machine Learning - Tom Mitchell
- Pattern Recognition and Machine Learning - Christopher M. Bishop
- Reinforcement Learning: An Introduction - Richard S. Sutton and Andrew G. Barto
- Deep Learning - Ian Goodfellow, Yoshua Bengio, Aaron Courville

Weitere (spezifische) Literatur zu einzelnen Themen wird in der Vorlesung angegeben.
# Course: Machine Learning and Optimization in Energy Systems [T-WIWI-113073]

| **Responsible:** | Prof. Dr. Wolf Fichtner |
| **Organisation:** | KIT Department of Economics and Management |
| **Part of:** | M-WIWI-101452 - Energy Economics and Technology |

| **Type** | Written examination |
| **Credits** | 4 |
| **Grading scale** | Grade to a third |
| **Recurrence** | Each winter term |
| **Version** | 3 |

## Exams

| ST 2024 | 7900207 | Machine Learning and Optimization in Energy Systems | Fichtner |

### Competence Certificate

The assessment of this course is a written examination (60 min) or an oral exam (30 min) depending on the number of participants.
4.179 Course: Management of IT-Projects [T-WIWI-112599]

**Responsible:** Dr. Roland Schätzle  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics

<table>
<thead>
<tr>
<th>Type</th>
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<th>Grading scale</th>
<th>Recurrence</th>
<th>Version</th>
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<tbody>
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<td>Grade to a third</td>
<td>see Annotations</td>
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**Events**

<table>
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<tr>
<th>ST 2024</th>
<th>2511214</th>
<th>Management of IT-Projects</th>
<th>2 SWS</th>
<th>Lecture / 🗣</th>
<th>Schätzle</th>
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<tbody>
<tr>
<td>ST 2024</td>
<td>2511215</td>
<td>Übungen zu Management von IT-Projekten</td>
<td>1 SWS</td>
<td>Practice / 🗣</td>
<td>Schätzle</td>
</tr>
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</table>

**Exams**

| ST 2024 | 79AIFB_MvIP_A1 | Management of IT-Projects (Registration until 15 July 2024) | Oberweis |

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

The examination will be offered for the last time in the summer semester 2024 for first-time writers. A repeat examination (only for repeaters) is possible for the last time in the winter semester 2024/2025.

Success is assessed in the form of a written examination (written exam) lasting 60 minutes.

**Prerequisites**

Prerequisite for the participation in the examination is the successful participation in the exercise, which takes place in the summer semester, starting from summer semester 2020. The number of participants in the exercise is limited.

**Annotation**

The lecture will be held for the last time in the summer semester 2024.

Below you will find excerpts from events related to this course:

**Management of IT-Projects**

| 2511214, SS 2024, 2 SWS, Language: German, Open in study portal | Lecture (V)  
| On-Site |
Content
The lecture deals with the general framework, impact factors and methods for planning, handling, and controlling of IT projects. Especially following topics are addressed:

- project environment
- project organisation
- project planning including the following items:
  - plan of the project structure
  - flow chart
  - project schedule
  - plan of resources
- effort estimation
- project infrastructure
- project controlling
- risk management
- feasibility studies
- decision processes, conduct of negotiations, time management.

Learning objectives:
Students

- explain the terminology of IT project management and typical used methods for planning, handling and controlling,
- apply methods appropiate to current project phases and project contexts,
- consider organisational and social impact factors.

Recommendations:
Knowledge from the lecture Software Engineering is helpful.

Workload:

- Lecture 30h
- Exercise 15h
- Preparation of lecture 24h
- Preparation of exercises 25h
- Exam preparation 40h
- Exam 1h

Literature

- B. Hindel, K. Hörmann, M. Müller, J. Schmied. Basiswissen Software-Projektmanagement. dpunkt.verlag 2004

Übungen zu Management von IT-Projekten
2511215, SS 2024, 1 SWS, Language: German, Open in study portal

Content
The general conditions, influencing factors and methods in the planning, execution and control of IT projects are dealt with. In particular, the following topics will be dealt with: Project environment, project organization, project structure plan, effort estimation, project infrastructure, project control, decision-making processes, negotiation, time management. The lecture is accompanied by exercises in the form of tutorials. The date of the exercise will be announced later.
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<thead>
<tr>
<th><strong>Course: Markov Decision Processes [T-MATH-105921]</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Responsible:</strong> Prof. Dr. Nicole Bäuerle</td>
</tr>
<tr>
<td><strong>Organisation:</strong> KIT Department of Mathematics</td>
</tr>
<tr>
<td><strong>Part of:</strong> M-MATH-102907 - Markov Decision Processes</td>
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<td>Grade to a third</td>
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**Prerequisites**

none
4.181 Course: Master's Thesis [T-MATH-105878]

**Responsible:** PD Dr. Stefan Kühnlein

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102917 - Master's Thesis

<table>
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<td>Grade to a third</td>
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</table>

**Final Thesis**
This course represents a final thesis. The following periods have been supplied:

- **Submission deadline**: 6 months
- **Maximum extension period**: 3 months
- **Correction period**: 8 weeks
4.182 Course: Matching Theory [T-WIWI-113264]

**Responsible:** Prof. Dr. Clemens Puppe  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101500 - Microeconomic Theory

<table>
<thead>
<tr>
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<td>3 SWS</td>
<td>Grade to a third</td>
<td>Each winter term</td>
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**Exams**  
| ST 2024 | 7900260 | Matching Theory | Puppe |

**Type**  
Written examination  
**Credits**  
4.5  
**Grading scale**  
Grade to a third  
**Recurrence**  
Each winter term  
**Version**  
1

**Events**  
WT 24/25  
2500042  
Matching Theory  
3 SWS  
Lecture / Practice  
Okulicz

**Exams**  
ST 2024  
7900260  
Matching Theory  
Puppe

**Legend:** 🖥 Online, 🤝 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**  
Written examination (90 minutes)

Below you will find excerpts from events related to this course:

**Content**  
How should we organize recruitment of students to schools? Could we improve the placement of doctors to hospitals? Why there always seems to be a better roommate to the one you currently have? Matching Theory answers all these questions and more. During the course we will formally study mathematical systems of allocating goods and people, and see their many real life applications from organizing kidney exchange to improving dating apps. The course will cover three main topics in Matching Theory and Market Design: (1) assignment problems (e.g., allocation of social housing), (2) two-sided matching (e.g., allocation of children to schools), (3) transferable-utility matching (e.g., labor market).

The students are expected to:

1. Understand the mathematical properties of allocations and commonly used mechanism  
2. Understand the connection between Matching Theory and real-life allocation systems  
3. Be able to use their knowledge to propose solutions for novel real-life problems
4.183 Course: Mathematical Methods in Signal and Image Processing [T-MATH-105862]

**Responsible:** Prof. Dr. Andreas Rieder

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102897 - Mathematical Methods in Signal and Image Processing

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<th>Grading scale</th>
<th>Version</th>
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<tr>
<td>Oral examination</td>
<td>8</td>
<td>Grade to a third</td>
<td>1</td>
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**Prerequisites**

none
4.184 Course: Mathematical Methods of Imaging [T-MATH-106488]

**Responsible:** Prof. Dr. Andreas Rieder  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-103260 - Mathematical Methods of Imaging

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<td>Mathematische Methoden der Bildgebung</td>
<td>Lecture</td>
<td>Rieder</td>
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<td>ST 2024</td>
<td>2 SWS</td>
<td>Übungen zu 0102900 (mathematische Methoden der Bildgebung)</td>
<td>Practice</td>
<td>Rieder</td>
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<th>Credits</th>
<th>Type</th>
<th>Responsible</th>
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<tbody>
<tr>
<td>ST 2024</td>
<td></td>
<td>Mathematical Methods of Imaging</td>
<td>Rieder</td>
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</table>

**Prerequisites**  
None
### 4.185 Course: Mathematical Modelling and Simulation in Practise [T-MATH-105889]

<table>
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<tr>
<th>Responsible</th>
<th>PD Dr. Gudrun Thäter</th>
</tr>
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<tbody>
<tr>
<td>Organisation</td>
<td>KIT Department of Mathematics</td>
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<tr>
<td>Part of</td>
<td>M-MATH-102929 - Mathematical Modelling and Simulation in Practise</td>
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<td><strong>Type</strong></td>
<td>Oral examination</td>
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<tr>
<td><strong>Credits</strong></td>
<td>4</td>
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<td><strong>Grading scale</strong></td>
<td>Grade to a third</td>
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<tr>
<td><strong>Version</strong></td>
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</table>
4.186 Course: Mathematical Physics [T-MATH-106113]

**Responsible:** Prof. Dr. Dirk Hundertmark

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-103079 - Mathematical Physics

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<td>Grade to a third</td>
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**Prerequisites**

none
4.187 Course: Mathematical Physics 2 [T-MATH-106526]

**Responsible:** Prof. Dr. Dirk Hundertmark

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-103274 - Mathematical Physics 2

<table>
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<td>Grade to a third</td>
<td>Irregular</td>
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</table>

**Prerequisites**

none
4.188 Course: Mathematical Statistics [T-MATH-105872]

Responsibles: Dr. rer. nat. Bruno Ebner
Prof. Dr. Vicky Fasen-Hartmann
PD Dr. Bernhard Klar
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics
Part of: M-MATH-102909 - Mathematical Statistics

<table>
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<td>Grade to a third</td>
<td>2</td>
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</table>

Exams

| ST 2024 | 7700112 | Mathematical Statistics | Fasen-Hartmann |

Prerequisites

none
Course: Mathematical Topics in Kinetic Theory [T-MATH-108403]

**Responsible:** Prof. Dr. Dirk Hundertmark

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-104059 - Mathematical Topics in Kinetic Theory

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<td>Grade to a third</td>
<td>Irregular</td>
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**Prerequisites**
none
Course: Mathematics for High Dimensional Statistics [T-WIWI-111247]

**Responsible:** Prof. Dr. Oliver Grothe

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101473 - Mathematical Programming

<table>
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<td>4,5</td>
<td>Grade to a third</td>
<td>Irregular</td>
<td>1</td>
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</table>

**Exams**

| ST 2024 | 7900362 | Mathematics for High Dimensional Statistics | Grothe |

**Competence Certificate**

The assessment consists of an oral exam (approx. 30 min.) taking place in the recess period.

**Prerequisites**

None

**Recommendation**

Basic knowledge of mathematics and statistics is assumed.

Knowledge in multivariate statistics is an advantage, but not necessary for the course.

**Annotation**

Teaching and learning format: Lecture and exercise
### 4.191 Course: Maxwell's Equations [T-MATH-105856]

| **Responsible:** | PD Dr. Tilo Arens  
|                  | Prof. Dr. Roland Griesmaier  
|                  | PD Dr. Frank Hettlich |
| **Organisation:** | KIT Department of Mathematics |
| **Part of:**     | M-MATH-102885 - Maxwell's Equations |

| **Type**         | Oral examination  |
| **Credits**      | 8  |
| **Grading scale**| Grade to a third |
| **Version**      | 1  |
### 4.192 Course: Medical Imaging Technology II [T-ETIT-113421]

**Responsible:** Prof. Dr.-Ing. Maria Francesca Spadea  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-106670 - Medical Imaging Technology II

#### Type  
- Written examination  
#### Credits  
- 3  
#### Grading scale  
- Grade to a third  
#### Recurrence  
- Each summer term  
#### Version  
- 1

<table>
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<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Version</th>
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<tbody>
<tr>
<td>ST 2024</td>
<td>2 SWS</td>
<td>Lecture / 🗣</td>
<td>Each summer term</td>
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<tbody>
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<td>2 SWS</td>
<td>Lecture / 🗣</td>
<td>Each summer term</td>
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</table>

**Competence Certificate**  
The examination takes place in form of a written examination lasting 90 minutes. The course grade is the grade of the written exam.

**Prerequisites**  
none
## 4.193 Course: Methods of Signal Processing [T-ETIT-100694]

**Responsible:** Prof. Dr.-Ing. Michael Heizmann  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100540 – Methods of Signal Processing

<table>
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<th>Recurrence</th>
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<td>Grade to a third</td>
<td>Each winter term</td>
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### Events

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<tbody>
<tr>
<td>WT 24/25</td>
<td>2302113</td>
<td>Methods of Signal Processing</td>
<td>2</td>
<td>Lecture / Online</td>
<td>Wahls</td>
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<tr>
<td>WT 24/25</td>
<td>2302115</td>
<td>Methods of Signal Processing (Tutorial to 2302113)</td>
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<td>Practice / On-Site</td>
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### Exams

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<tr>
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<th>Course</th>
<th>Lecturer(s)</th>
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<tr>
<td>ST 2024</td>
<td>7302113</td>
<td>Methods of Signal Processing</td>
<td>Wahls</td>
</tr>
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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

### Prerequisites

none
4.194 Course: Metric Geometry [T-MATH-111933]

**Responsible:** Prof. Dr. Alexander Lytchak
Dr. Artem Nepechiy

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105931 - Metric Geometry

<table>
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**Competence Certificate**
oral examination of circa 20 minutes

**Prerequisites**
none
4 COURSES

T 4.195 Course: Minimal Surfaces [T-MATH-113417]

<table>
<thead>
<tr>
<th>Responsible</th>
<th>Dr. Peter Lewintan</th>
</tr>
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<tbody>
<tr>
<td>Organisation</td>
<td>KIT Department of Mathematics</td>
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<tr>
<td>Part of</td>
<td>M-MATH-106666 - Minimal Surfaces</td>
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</table>

Prerequisites
None
4.196 Course: Mixed Integer Programming I [T-WIWI-102719]

**Responsible:** Prof. Dr. Oliver Stein  
**Organisation:** KIT Department of Economics and Management  
**Part of:**  
- M-WIWI-101473 - Mathematical Programming  
- M-WIWI-102832 - Operations Research in Supply Chain Management

<table>
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**Events**

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<th>Lecturer</th>
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<tr>
<td>ST 2024</td>
<td>2550140</td>
<td>2</td>
<td>Lecture / 🗣</td>
<td>Stein</td>
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**Exams**

<table>
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<th>Location</th>
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<tr>
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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

The assessment of the lecture is a written examination (60 minutes) according to §4(2), 1 of the examination regulation. The successful completion of the exercises is required for admission to the written exam.

The examination is held in the semester of the lecture and in the following semester.

The examination can also be combined with the examination of Mixed Integer Programming II [25140]. In this case, the duration of the written examination takes 120 minutes.

**Prerequisites**

None

**Recommendation**

It is strongly recommended to visit at least one lecture from the Bachelor program of this chair before attending this course.

**Annotation**

The lecture is offered irregularly. The curriculum of the next three years is available online (kop.ior.kit.edu).

Below you will find excerpts from events related to this course:

**Mixed-integer Programming II**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>ST 2024</td>
<td>2550140</td>
<td>2</td>
<td>German</td>
<td>Open in study portal</td>
</tr>
</tbody>
</table>
Content
Many optimization problems from economics, engineering and natural sciences are modeled with continuous as well as with discrete variables. Examples are the energy minimal design of a chemical process in which several reactors may be switched on or off, portfolio optimization with limitations on the number of securities, the choice of locations to serve customers at minimum cost, and the optimal design of vote allocations in election procedures. For the algorithmic identification of optimal points of such problems an interaction of ideas from discrete as well as continuous optimization is necessary.

The lecture focusses on mixed-integer nonlinear optimization problems and is structured as follows:

- Continuous relaxation and error bounds for roundings
- Branch-and-Bound for convex and nonconvex problems
- Generalized Benders decomposition
- Outer approximation methods
- Lagrange relaxation
- Dantzig-Wolfe decomposition
- Heuristics

The lecture is accompanied by exercises which, amongst others, offers the opportunity to implement and to test some of the methods on practically relevant examples.

Remark:
The treatment of mixed-integer linear optimization problems forms the contents of the lecture "Mixed-integer Programming I".

Learning objectives:
The student

- knows and understands the fundamentals of nonlinear mixed integer programming,
- is able to choose, design and apply modern techniques of nonlinear mixed integer programming in practice.

Literature

- J. Kallrath: Gemischt-ganzzahlige Optimierung, Vieweg, 2002
- D. Li, X. Sun: Nonlinear Integer Programming, Springer, 2006
4.197 Course: Mixed Integer Programming II [T-WIWI-102720]

**Responsible:** Prof. Dr. Oliver Stein

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101473 - Mathematical Programming
- M-WIWI-102832 - Operations Research in Supply Chain Management

<table>
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<th>Recurrence</th>
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**Events**

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<th>Grading scale</th>
<th>Recurrence</th>
<th>Version</th>
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<tr>
<td>ST 2024 2550140</td>
<td>Mixed-integer Programming II</td>
<td>2 SWS</td>
<td>Lecture / 🗣️</td>
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<tr>
<td>ST 2024 2550141</td>
<td>Exercise to Mixed-integer Programming II</td>
<td>1 SWS</td>
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**Exams**

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<td>Mixed Integer Programming II</td>
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<td>Stein</td>
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</table>

Legend: 🖥 Online, 🗬 Blended (On-Site/Online), 🗣️ On-Site, ✗ Cancelled

**Competence Certificate**

The assessment of the lecture is a written examination (60 minutes) according to §4(2), 1 of the examination regulation. The successful completion of the exercises is required for admission to the written exam. The examination is held in the semester of the lecture and in the following semester. The examination can also be combined with the examination of Mixed Integer Programming I [2550138]. In this case, the duration of the written examination takes 120 minutes.

**Prerequisites**

None

**Recommendation**

It is strongly recommended to visit at least one lecture from the Bachelor program of this chair before attending this course.

**Annotation**

The lecture is offered irregularly. The curriculum of the next three years is available online (kop.ior.kit.edu).

Below you will find excerpts from events related to this course:

<table>
<thead>
<tr>
<th>V Mixed-integer Programming II</th>
<th>Lecture (V)</th>
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<tbody>
<tr>
<td>2550140 SS 2024, 2 SWS, Language: German</td>
<td>On-Site</td>
</tr>
</tbody>
</table>
Content
Many optimization problems from economics, engineering and natural sciences are modeled with continuous as well as with discrete variables. Examples are the energy minimal design of a chemical process in which several reactors may be switched on or off, portfolio optimization with limitations on the number of securities, the choice of locations to serve customers at minimum cost, and the optimal design of vote allocations in election procedures. For the algorithmic identification of optimal points of such problems an interaction of ideas from discrete as well as continuous optimization is necessary.

The lecture focusses on mixed-integer nonlinear optimization problems and is structured as follows:

- Continuous relaxation and error bounds for roundings
- Branch-and-Bound for convex and nonconvex problems
- Generalized Benders decomposition
- Outer approximation methods
- Lagrange relaxation
- Dantzig-Wolfe decomposition
- Heuristics

The lecture is accompanied by exercises which, amongst others, offers the opportunity to implement and to test some of the methods on practically relevant examples.

Remark:
The treatment of mixed-integer linear optimization problems forms the contents of the lecture "Mixed-integer Programming I".

Learning objectives:
The student

- knows and understands the fundamentals of nonlinear mixed integer programming,
- is able to choose, design and apply modern techniques of nonlinear mixed integer programming in practice.

Literature

- J. Kallrath: Gemisch-t-ganzzahlige Optimierung, Vieweg, 2002
- D. Li, X. Sun: Nonlinear Integer Programming, Springer, 2006
4.198 Course: Modeling and OR-Software: Advanced Topics [T-WIWI-106200]

**Responsible:** Prof. Dr. Stefan Nickel

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-102832 - Operations Research in Supply Chain Management

<table>
<thead>
<tr>
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<th>Version</th>
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<td>Each winter term</td>
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**Events**

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<th>Recurrence</th>
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<td>3 SWS</td>
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<tr>
<td>2550490</td>
<td>Modellieren und OR-Software: Fortgeschrittene Themen</td>
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<td>ST 2024</td>
<td>Modeling and OR-Software: Advanced Topics</td>
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<td>7900188</td>
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<td>Modeling and OR-Software: Advanced Topics</td>
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**Exams**

**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Competence Certificate**

The assessment is a written examination. The examination is held in every semester. The prerequisite can only be obtained in semesters in which the course exercises are offered.

**Prerequisites**

Prerequisite for admission to the exam is the successful participation in the exercises. This includes the processing and presentation of exercises.

**Recommendation**

Basic knowledge as conveyed in the module *Introduction to Operations Research* is assumed.

Successful completion of the course *Modeling and OR-Software: Introduction*.

**Annotation**

Due to capacity restrictions, registration before course start is required. For further information see the webpage of the course.

The lecture is held in every term. The planned lectures and courses for the next three years are announced online.

**Below you will find excerpts from events related to this course:**

**Modellieren und OR-Software: Fortgeschrittene Themen**

2550490, WS 24/25, 3 SWS, Language: German, [Open in study portal](http://go.wiwi.kit.edu/OR_Bewerbung)

**Content**

The advanced course is designated for Master students that already attended the introductory course or gained equivalent experience elsewhere, e.g. during a seminar or bachelor thesis. We will work on advanced topics and methods in OR, among others cutting planes, column generation and constraint programming. The Software used for the exercises is IBM ILOG CPLEX Optimization Studio. The associated modelling programming languages are OPL and ILOG Script.

**Organizational issues**

Link zur Bewerbung:

[http://go.wiwi.kit.edu/OR_Bewerbung](http://go.wiwi.kit.edu/OR_Bewerbung)

Bewerberzeitraum:

01.09.2023 00:00 - 12.10.2023 23:55
**Course: Modeling and OR-Software: Introduction [T-WIWI-106199]**

**Responsible:** Prof. Dr. Stefan Nickel

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101413 - Applications of Operations Research

**Type**
- Written examination

**Credits**
- 4,5

**Grading scale**
- Grade to a third

**Recurrence**
- Each summer term

**Version**
- 4

**Events**

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<td>Grade to a third</td>
<td>Practical course / Blended (On-Site/Online)</td>
<td>Each summer term</td>
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<td>Nickel, Linner, Pomes</td>
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**Exams**

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<td>Modeling and OR-Software: Introduction</td>
<td>Nickel</td>
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<td>WT 24/25</td>
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<td>Nickel</td>
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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Competence Certificate**
The assessment is a written examination. The examination is held in every semester. The prerequisite can only be obtained in semesters in which the course exercises are offered.

**Recommendation**

**Annotation**
Due to capacity restrictions, registration before course start is required. For further information see the webpage of the course.

The lecture is offered in every term. The planned lectures and courses for the next three years are announced online.

Below you will find excerpts from events related to this course:

**Modellieren und OR-Software: Einführung**

<table>
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<th>Type</th>
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<tbody>
<tr>
<td>3 SWS</td>
<td>Blended (On-Site/Online)</td>
<td>Nickel</td>
</tr>
</tbody>
</table>

**Content**
After an introduction to general concepts of modelling tools (implementation, data handling, result interpretation, ...), the software IBM ILOG CPLEX Optimization Studio and the corresponding modeling language OPL will be discussed which can be used to solve OR problems on a computer-aided basis. Subsequently, a broad range of exercises will be discussed. The main goals of the exercises from literature and practical applications are to learn the process of modeling optimization problems as linear or mixed-integer programs, to efficiently utilize the presented tools for solving these optimization problems and to implement heuristic solution procedures for mixed-integer programs.

**Organizational issues**
Die Teilnehmerzahl für diese Veranstaltung ist begrenzt.
Die Bewerbung erfolgt über das Wiwi-Portal.
Der Bewerbungszeitraum ist vom 01.03.24 bis zum 18.03.24.
4.200 Course: Modeling and Simulation [T-WIWI-112685]

**Responsible:** Prof. Dr. Sanja Lazarova-Molnar  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics

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<td>Each summer term</td>
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<td>Modeling and Simulation</td>
<td>2 SWS Lecture</td>
<td>Lazarova-Molnar</td>
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<td>ST 2024</td>
<td>251101</td>
<td>Exercises Modeling and</td>
<td>1 SWS Practice</td>
<td>Lazarova-Molnar</td>
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<td>Simulation</td>
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<td>79AIFB_MaS_C6</td>
<td>Modeling and Simulation (Registration until 15 July 2024)</td>
<td>Lazarova-Molnar</td>
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</table>

**Competence Certificate**  
Depending on the number of participants in the course, the exam will be offered either as an oral exam (20 min), or as a written exam (60 min).  
The exam takes place every semester and can be repeated at every regular examination date.

**Prerequisites**  
None

**Recommendation**  
Some experience in programming and knowledge of basic mathematics and statistics.

**Annotation**  
Instruction is in the form of lectures and exercises. A detailed course schedule will be published before the start of the semester.

Below you will find excerpts from events related to this course:

**Modeling and Simulation**  
251100, SS 2024, 2 SWS, Language: English, [Open in study portal](#)
Content
Modeling and Simulation is the most widely used operations research / systems engineering technique for designing new systems and optimizing the performance of existing systems. In one way or another, just about every engineering or scientific field uses simulation as an exploration, modeling, or analysis technique. The course is designed to provide students with basic knowledge of modeling and simulation approaches and to provide them with first experience of using a simulation package. The course will focus on modeling and simulation of real-world discrete event systems. Examples of discrete events are customer arrivals at a queue of a service desk, machine failures in manufacturing systems, telephone calls in a call center, etc. Moreover, continuous and hybrid models will be also discussed. Topics include Discrete-Event Simulation, Input Modeling, Output Analysis, Random Number Generation, Verification and Validation, Stochastic Petri Nets and Markov Chains.

Competence Certificate
Depending on the number of participants in the course, the exam will be offered either as an oral exam (20 min), or as a written exam (60 min).
The exam takes place every semester and can be repeated at every regular examination date.

Learning Objectives
Knowledge:
- Demonstrate knowledge about general and specific theories, challenges, algorithms, methods, technologies, and tools related to modelling and simulation
- Demonstrate knowledge of two important classes of simulation:
  - Discrete-event Monte-Carlo simulation,
  - Continuous simulation with ODEs
- Demonstrate knowledge of algorithms necessary to build a simulator

Skills:
- Analyse suitability of an approach/tool for a given modelling problem
- Understand simulation models of various types
- Demonstrate methods and techniques to overcome common challenges in modelling and simulation
- Model simulation input data
- Analyse and model discrete stochastic systems
- Analyse and interpret simulation results

Competences:
- Use different methods to conduct simulation-based analysis of real-world data
- Build and simulate stochastic models
- Use simulation software

Prerequisites
Some experience in programming and knowledge of basic mathematics and statistics

Form of instruction
Lectures and exercises. A detailed course plan will be published before the semester start.

Literature
Discrete-Event System Simulation, 5th Edition
Jerry Banks, John S. Carson, II, Barry L. Nelson and David M. Nicol
4.201 Course: Modelling and Simulation of Lithium-Ion Batteries [T-MATH-113382]

**Responsible:** Prof. Dr. Willy Dörfler

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-106640 - Modelling and Simulation of Lithium-Ion Batteries

<table>
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<tr>
<td>Oral examination</td>
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<td>Grade to a third</td>
<td>1</td>
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</table>

**Competence Certificate**
oral exam (ca. 20 min)

**Prerequisites**
None
4.202 Course: Models of Mathematical Physics [T-MATH-105846]

**Responsible:** Prof. Dr. Dirk Hundertmark
Prof. Dr. Michael Plum
Prof. Dr. Wolfgang Reichel

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102875 - Models of Mathematical Physics

<table>
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<th>Grading scale</th>
<th>Version</th>
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<tbody>
<tr>
<td>Oral examination</td>
<td>8</td>
<td>Grade to a third</td>
<td>1</td>
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</table>
4.203 Course: Modern Experimental Physics I, Atoms, Nuclei and Molecules [T-PHYS-112846]

**Responsible:** Studiendekan Physik

**Organisation:** KIT Department of Physics

**Part of:** M-PHYS-106331 - Modern Experimental Physics I, Atoms, Nuclei and Molecules

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<td>8</td>
<td>Grade to a third</td>
<td>Each summer term</td>
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**Events**

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<th>4010041</th>
<th>Modern Experimental Physics I, Atoms, Nuclei and Molecules</th>
<th>4 SWS</th>
<th>Lecture / 🗣</th>
<th>Müller</th>
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<tr>
<td>ST 2024</td>
<td>4010042</td>
<td>Übungen zu Moderne Experimentalphysik I</td>
<td>2 SWS</td>
<td>Practice / 🗣</td>
<td>Müller, Hinz</td>
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</table>

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

Oral exam, approx. 45 min

**Prerequisites**

successful completion of the exercises

**Modeled Conditions**

The following conditions have to be fulfilled:

1. The following conditions have to be fulfilled:
4.204 Course: Modern Experimental Physics II, Structure of Matter [T-PHYS-112847]

**Responsible:** Studiendekan Physik

**Organisation:** KIT Department of Physics

**Part of:** M-PHYS-106332 - Modern Experimental Physics II, Structure of Matter

<table>
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<th>Recurrence</th>
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**Events**

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<th>Credits</th>
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<tr>
<td>WT 24/25</td>
<td>4010051</td>
<td>Moderne Experimentalphysik II (Struktur der Materie)</td>
<td>4 SWS</td>
<td>Lecture / 🗣</td>
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<td>Klute, Ustinov</td>
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<tr>
<td>WT 24/25</td>
<td>4010052</td>
<td>Übungen zu Moderne Experimentalphysik II</td>
<td>2 SWS</td>
<td>Practice / 🗣</td>
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<td>Klute, Ustinov, NN, Fischer</td>
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</table>

Legend: 🖥 Online, ☑ Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**
Oral exam, approx. 45 min

**Prerequisites**
Successful completion of the exercises

**Modeled Conditions**
The following conditions have to be fulfilled:

1. The following conditions have to be fulfilled:
Course: Modern Theoretical Physics I, Foundations of Quantum Mechanics [T-PHYS-112848]

**Responsible:** Studiendekan Physik

**Organisation:** KIT Department of Physics

**Part of:** M-PHYS-106334 - Modern Theoretical Physics I, Foundations of Quantum Mechanics

**Type:** Oral examination

**Credits:** 8

**Grading scale:** Grade to a third

**Recurrence:** Each summer term

**Version:** 1

### Events

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<th>Event Code</th>
<th>Event Type</th>
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**Exams**

Legend: 🖥 Online, ☢ Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

### Competence Certificate

Oral exam, approx. 45 min

### Prerequisites

none
### 4.206 Course: Modern Theoretical Physics II, Advanced Quantum Mechanics and Statistical Physics [T-PHYS-112849]

**Responsible:** Studiendekan Physik  
**Organisation:** KIT Department of Physics  
**Part of:** M-PHYS-106335 - Modern Theoretical Physics II, Advanced Quantum Mechanics and Statistical Physics

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Legend: 🖥 Online, ⛔ Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**  
Oral exam, approx. 45 min

**Prerequisites**  
none
4.207 Course: Modular Forms [T-MATH-105843]

**Responsible:** PD Dr. Stefan Kühnlein

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102868 - Modular Forms

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### 4.208 Course: Monotonicity Methods in Analysis [T-MATH-105877]

**Responsible:** PD Dr. Gerd Herzog  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102887 - Monotonicity Methods in Analysis

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4.209 Course: Multicriteria Optimization [T-WIWI-111587]

**Responsibility:** Prof. Dr. Oliver Stein

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101473 - Mathematical Programming
- M-WIWI-102832 - Operations Research in Supply Chain Management

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**Exams**

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**Legend:** 📥 Online, 💭 Blended (On-Site/Online), 🏙 On-Site, ❌ Cancelled

**Competence Certificate**

The assessment of the lecture is a written examination (60 minutes) according to §4(2), 1 of the examination regulation. The successful completion of the exercises is required for admission to the written exam. The examination is held in the semester of the lecture and in the following semester.

**Prerequisites**

None

**Recommendation**

It is strongly recommended to visit at least one lecture from the Bachelor program of this chair before attending this course.

**Annotation**

The course is offered every second winter semester (starting WiSe 22/23). The curriculum of the next three years is available online (www.ior.kit.edu).

Contents:

Multicriteria optimization deals with optimization problems with multiple objective functions. In practice, the minimization or maximization of several objectives often conflict with each other, such as weight and stability of mechanical components, return and risk of stock portfolios, or cost and duration of transports. Various scalarization approaches allow one to formulate single-objective problems that can be solved using nonlinear or global optimization techniques, and whose optimal points have a reasonable interpretation for the underlying multicriteria problem.

However, some seemingly obvious scalarization approaches suffer from various drawbacks, so that regardless of scalarization approaches, it is necessary to clarify what is meant by the solution of a multicriteria optimization problem in the first place. For such Pareto-optimal points, optimality conditions and solution procedures based on them can be formulated. From the usually non-unique Pareto set, decision makers finally choose an alternative based on their subjective preferences.

The lecture gives a mathematically sound introduction to multicriteria optimization and is structured as follows:

- Introductory examples and terminology
- Solution concepts
- Methods for the determination of the Pareto set
- Selection of Pareto-optimal points under subjective preferences

Below you will find excerpts from events related to this course:
Content
Multicriteria optimization deals with optimization problems with multiple objective functions. In practice, the minimization or maximization of several objectives often conflict with each other, such as weight and stability of mechanical components, return and risk of stock portfolios, or cost and duration of transports. Various scalarization approaches allow one to formulate single-objective problems that can be solved using nonlinear or global optimization techniques, and whose optimal points have a reasonable interpretation for the underlying multicriteria problem.

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The lecture gives a mathematically sound introduction to multicriteria optimization and is structured as follows:

- Introductory examples and terminology
- Solution concepts
- Methods for the determination of the Pareto set
- Selection of Pareto-optimal points under subjective preferences

Learning objectives:
The student

- knows and understands the fundamentals of multicriteria optimization,
- is able to choose, design and apply modern techniques of multicriteria optimization in practice.

Literature

4.210 Course: Multigrid and Domain Decomposition Methods [T-MATH-105863]

**Responsible:** Prof. Dr. Christian Wieners

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102898 - Multigrid and Domain Decomposition Methods

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**Competence Certificate**
Mündliche Prüfung im Umfang von ca. 20 Minuten.

**Prerequisites**
none
4.211 Course: Multivariate Statistical Methods [T-WIWI-103124]

**Responsible:** Prof. Dr. Oliver Grothe

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101473 - Mathematical Programming

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Legend: 🖥 Online, 🕹️ Blended (On-Site/Online), 🗣️ On-Site, ❌ Cancelled

**Competence Certificate**

Written examination lasting 60 minutes.

The examination is offered during the examination period of the lecture semester. Only repeaters (and not first-time writers) are admitted to the repeat examination in the examination period of the following semester.

**Prerequisites**

None

**Recommendation**

The course covers highly advanced statistical methods with a quantitative focus. Hence, participants are necessarily expected to have advanced statistical knowledge, e.g. acquired in the course "Advanced Statistics". Without this, participation in the course is not advised.

Previous attendance of the course Analysis of Multivariate Data is recommended. Alternatively, the script can be provided to interested students.

**Annotation**

The course (lecture and exercise) is offered irregularly. Detailed information can be found on the chair's website.

Responsible: Prof. Dr. Pradyumn Kumar Shukla
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

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Exams

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🔝 On-Site, ✗ Cancelled

Competence Certificate

Please note: no exam can be offered in the winter semester 2023/2024.

Prerequisites

None

Below you will find excerpts from events related to this course:

**Nature-Inspired Optimization Methods**

2511106, SS 2024, 2 SWS, Language: English, Open in study portal

Lecture (V) Blended (On-Site/Online)

Content

Many optimization problems are too complex to be solved to optimality. A promising alternative is to use stochastic heuristics, based on some fundamental principles observed in nature. Examples include evolutionary algorithms, ant algorithms, or simulated annealing. These methods are widely applicable and have proven very powerful in practice. During the course, such optimization methods based on natural principles are presented, analyzed and compared. Since the algorithms are usually quite computational intensive, possibilities for parallelization are also investigated.

Learning objectives:

Students learn:

- Different nature-inspired methods: local search, simulated annealing, tabu search, evolutionary algorithms, ant colony optimization, particle swarm optimization
- Different aspects and limitation of the methods
- Applications of such methods
- Multi-objective optimization methods
- Constraint handling methods
- Different aspects in parallelization and computing platforms

Literature

* E. Bonabeau, M. Dorigo, G. Theraulaz: 'Swarm Intelligence'. Oxford University Press, 1999
* Springer, 2003

**Responsible:** Prof. Dr. Martina Zitterbart  
**Organisation:** KIT Department of Informatics  
**Part of:** M-INFO-100782 - Network Security: Architectures and Protocols

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**Events**

| ST 2024 | 24601 | Netz sicherheit: Architekturen und Protokolle | 2 SWS | Lecture / 🗣 | Baumgart, Bless, Zitterbart |

**Exams**

| ST 2024 | 7500072 | Network Security: Architectures and Protocols | | Zitterbart, Bless, Baumgart |

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled
4.214 Course: Nonlinear Analysis [T-MATH-107065]

**Responsible:** Prof. Dr. Tobias Lamm  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-103539 - Nonlinear Analysis

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**Prerequisites**  
none
### Course: Nonlinear Control Systems [T-ETIT-100980]

**Responsible:** Dr.-Ing. Mathias Kluwe  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100371 - Nonlinear Control Systems

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

#### Prerequisites

none
4.216 Course: Nonlinear Evolution Equations [T-MATH-105848]

**Responsible:** Prof. Dr. Dorothee Frey  
Prof. Dr. Roland Schnaubelt

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102877 - Nonlinear Evolution Equations

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Below you will find excerpts from events related to this course:

**Nonlinear Evolution Equations**  
0156500, SS 2024, 4 SWS, Open in study portal

**Lecture (V)**

**Content**

Evolution equations describe the change in time of dynamical systems via an ordinary differential equation in a Banach or Hilbert space. In this lecture we study nonlinear and autonomous (time invariant) problems, whose main part is given by a generator of a linear, strongly continuous operator semigroup. In particular, we treat reaction diffusion systems and semilinear wave and Schrödinger equations.

Typical topics are existence and uniqueness, continuous dependence on data, blow-up versus global-in time existence, regularity, or the longtime behavior near equilibria. Many of the results and methods are inspired by the theory of ordinary differential equations (Analysis 4), though the presence of unbounded operators in Banach spaces leads to many new and deep difficulties and phenomena. Our approach essentially relies on a functional analytic way of thinking.

The moduls functional analysis and evolution equations are strongly recommended. The necessary contents of the latter lecture will be briefly recalled though.
### 4.217 Course: Nonlinear Functional Analysis [T-MATH-105876]

**Responsible:** PD Dr. Gerd Herzog  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102886 - Nonlinear Functional Analysis

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Mathematics Master 2016 (Master of Science (M.Sc.))  
Module Handbook as of 09/07/2024
### 4.218 Course: Nonlinear Maxwell Equations [T-MATH-110283]

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<th>Prof. Dr. Roland Schnaubelt</th>
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**Prerequisites**
none
4.219 Course: Nonlinear Optimization I [T-WIWI-102724]

**Responsible:** Prof. Dr. Oliver Stein  
**Organisation:** KIT Department of Economics and Management

Part of:  
M-WIWI-101414 - Methodical Foundations of OR  
M-WIWI-101473 - Mathematical Programming

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<td>2550112</td>
<td>Exercises Nonlinear Optimization I + II</td>
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<td>Practice / On-Site</td>
<td>Stein, Schwarze</td>
</tr>
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</table>

**Exams**

<table>
<thead>
<tr>
<th>Event</th>
<th>Code</th>
<th>Title</th>
<th>Type / Location</th>
<th>Instructor(s)</th>
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<tr>
<td>ST 2024</td>
<td>7900202_SS2024_NK</td>
<td>Nonlinear Optimization I</td>
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<td>Stein</td>
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<tr>
<td>WT 24/25</td>
<td>7900001_WS2425_HK</td>
<td>Nonlinear Optimization I</td>
<td></td>
<td>Stein</td>
</tr>
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</table>

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

**Competence Certificate**

The assessment consists of a written exam (60 minutes) according to Section 4(2), 1 of the examination regulation. The successful completion of the exercises is required for admission to the written exam. The exam takes place in the semester of the lecture and in the following semester.

The examination can also be combined with the examination of Nonlinear Optimization II [2550113]. In this case, the duration of the written examination takes 120 minutes.

**Prerequisites**

The module component exam T-WIWI-103637 "Nonlinear Optimization I and II" may not be selected.

**Annotation**

Part I and II of the lecture are held consecutively in the same semester.

Below you will find excerpts from events related to this course:

**Nonlinear Optimization I**

2550111, WS 24/25, 2 SWS, Language: German, [Open in study portal](#)
Content
The lecture treats the minimization of smooth nonlinear functions without constraints. For such problems, which occur very often in economics, engineering, and natural sciences, optimality conditions are derived and, based on them, solution algorithms are developed. The lecture is structured as follows:

- Introduction, examples, and terminology
- Existence results for optimal points
- First and second order optimality conditions
- Algorithms (line search, steepest descent method, variable metric methods, Newton method, Quasi Newton methods, CG method, trust region method)

The lecture is accompanied by exercises which, amongst others, offers the opportunity to implement and to test some of the methods on practically relevant examples.

Remark:
The treatment of optimization problems with constraints forms the contents of the lecture "Nonlinear Optimization II". The lectures "Nonlinear Optimization I" and "Nonlinear Optimization II" are held consecutively in the same semester.

Learning objectives:
The student

- knows and understands fundamentals of unconstrained nonlinear optimization,
- is able to choose, design and apply modern techniques of unconstrained nonlinear optimization in practice.

Literature

Weiterführende Literatur:

- W. Alt, Nichtlineare Optimierung, Vieweg, 2002
- M.S. Bazaraa, H.D. Sherali, C.M. Shetty, Nonlinear Programming, Wiley, 1993
4.220 Course: Nonlinear Optimization I and II [T-WIWI-103637]

**Responsible:** Prof. Dr. Oliver Stein  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101414 - Methodical Foundations of OR  
M-WIWI-101473 - Mathematical Programming

<table>
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**Events**

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<th>Grading scale</th>
<th>Recurrence</th>
<th>Version</th>
</tr>
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<tbody>
<tr>
<td>WT 24/25</td>
<td>Nonlinear Optimization I</td>
<td>2 SWS</td>
<td>Lecture / 🗣️</td>
<td>Stein</td>
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</tr>
<tr>
<td>WT 24/25</td>
<td>Exercises Nonlinear Optimization I + II</td>
<td>2 SWS</td>
<td>Practice / 🗣️</td>
<td>Stein, Schwarze</td>
<td></td>
</tr>
<tr>
<td>WT 24/25</td>
<td>Nonlinear Optimization II</td>
<td>2 SWS</td>
<td>Lecture / 🗣️</td>
<td>Stein</td>
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**Exams**

<table>
<thead>
<tr>
<th>Exams</th>
<th>Type</th>
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<td>Each winter term</td>
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<td>Nonlinear Optimization I and II</td>
<td>90 minutes</td>
<td>Grade to a third</td>
<td>Each winter term</td>
<td>6</td>
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</table>

Legend: 🖥️ Online, 🪜 Blended (On-Site/Online), 🗣️ On-Site, ✗ Cancelled  

**Competence Certificate**

The assessment consists of a written exam (120 minutes) according to Section 4(2), 1 of the examination regulation. The successful completion of the exercises is required for admission to the written exam. The exam takes place in the semester of the lecture and in the following semester.

**Prerequisites**

None.

**Modeled Conditions**

The following conditions have to be fulfilled:

1. The course T-WIWI-102724 - Nonlinear Optimization I must not have been started.
2. The course T-WIWI-102725 - Nonlinear Optimization II must not have been started.

**Annotation**

Part I and II of the lecture are held consecutively in the same semester.

Below you will find excerpts from events related to this course:

**Nonlinear Optimization I**

2550111, WS 24/25, 2 SWS, Language: German, [Open in study portal](#)
Content
The lecture treats the minimization of smooth nonlinear functions without constraints. For such problems, which occur very often in economics, engineering, and natural sciences, optimality conditions are derived and, based on them, solution algorithms are developed. The lecture is structured as follows:

- Introduction, examples, and terminology
- Existence results for optimal points
- First and second order optimality conditions
- Algorithms (line search, steepest descent method, variable metric methods, Newton method, Quasi Newton methods, CG method, trust region method)

The lecture is accompanied by exercises which, amongst others, offers the opportunity to implement and to test some of the methods on practically relevant examples.

Remark:
The treatment of optimization problems with constraints forms the contents of the lecture "Nonlinear Optimization II". The lectures "Nonlinear Optimization I" and "Nonlinear Optimization II" are held consecutively in the same semester.

Learning objectives:
The student

- knows and understands fundamentals of unconstrained nonlinear optimization,
- is able to choose, design and apply modern techniques of unconstrained nonlinear optimization in practice.

Literature

Weiterführende Literatur:

- W. Alt, Nichtlineare Optimierung, Vieweg, 2002
- M.S. Bazaraa, H.D. Sherali, C.M. Shetty, Nonlinear Programming, Wiley, 1993

Content
The lecture treats the minimization of smooth nonlinear functions under nonlinear constraints. For such problems, which occur very often in economics, engineering, and natural sciences, optimality conditions are derived and, based on them, solution algorithms are developed. The lecture is structured as follows:

- Topology and first order approximations of the feasible set
- Theorems of the alternative, first and second order optimality conditions
- Algorithms (penalty method, multiplier method, barrier method, interior point method, SQP method, quadratic optimization)

The lecture is accompanied by exercises which, amongst others, offers the opportunity to implement and to test some of the methods on practically relevant examples.

Remark:
The treatment of optimization problems without constraints forms the contents of the lecture "Nonlinear Optimization I". The lectures "Nonlinear Optimization I" and "Nonlinear Optimization II" are held consecutively in the same semester.

Learning objectives:
The student

- knows and understands fundamentals of constrained nonlinear optimization,
- is able to choose, design and apply modern techniques of constrained nonlinear optimization in practice.
Literature

Weiterführende Literatur:

- W. Alt, Nichtlineare Optimierung, Vieweg, 2002
- M.S. Bazaraa, H.D. Sherali, C.M. Shetty, Nonlinear Programming, Wiley, 1993
4.221 Course: Nonlinear Optimization II [T-WIWI-102725]

**Responsible:** Prof. Dr. Oliver Stein

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101414 - Methodical Foundations of OR
- M-WIWI-101473 - Mathematical Programming

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<th>Stein, Schwarze</th>
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<tr>
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<td>2550113</td>
<td>Nonlinear Optimization II 2 SWS</td>
<td>Lecture / 🗣</td>
<td>Stein</td>
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**Exams**

| ST 2024    | 7900203_SS2024_NK | Nonlinear Optimization II              |               | Stein           |
| WT 24/25   | 7900002_WS2425_HK | Nonlinear Optimization II              |               | Stein           |

Legend: 🖥 Online, ☐ Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

The assessment consists of a written exam (60 minutes) according to Section 4(2), 1 of the examination regulation. The successful completion of the exercises is required for admission to the written exam. The exam takes place in the semester of the lecture and in the following semester. The exam can also be combined with the examination of Nonlinear Optimization I [2550111]. In this case, the duration of the written exam takes 120 minutes.

**Prerequisites**

None.

**Modeled Conditions**

The following conditions have to be fulfilled:

1. The course T-WIWI-103637 - Nonlinear Optimization I and II must not have been started.

**Annotation**

Part I and II of the lecture are held consecutively in the same semester.

**Below you will find excerpts from events related to this course:**

**Nonlinear Optimization II**

2550113, WS 24/25, 2 SWS, Language: German, [Open in study portal](#)
Content
The lecture treats the minimization of smooth nonlinear functions under nonlinear constraints. For such problems, which occur very often in economics, engineering, and natural sciences, optimality conditions are derived and, based on them, solution algorithms are developed. The lecture is structured as follows:

- Topology and first order approximations of the feasible set
- Theorems of the alternative, first and second order optimality conditions
- Algorithms (penalty method, multiplier method, barrier method, interior point method, SQP method, quadratic optimization)

The lecture is accompanied by exercises which, amongst others, offers the opportunity to implement and to test some of the methods on practically relevant examples.

Remark:
The treatment of optimization problems without constraints forms the contents of the lecture "Nonlinear Optimization I". The lectures "Nonlinear Optimization I" and "Nonlinear Optimization II" are held consecutively in the same semester.

Learning objectives:
The student

- knows and understands fundamentals of constrained nonlinear optimization,
- is able to choose, design and apply modern techniques of constrained nonlinear optimization in practice.

Literature

Weiterführende Literatur:
- W. Alt, Nichtlineare Optimierung, Vieweg, 2002
- M.S. Bazaraa, H.D. Sherali, C.M. Shetty, Nonlinear Programming, Wiley, 1993
4.222 Course: Nonlinear Schroedinger and Wave Equations [T-MATH-106121]

**Responsible:** Prof. Dr. Lutz Weis

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-103086 - Nonlinear Schroedinger and Wave Equations

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<td>Grade to a third</td>
<td>Irregular</td>
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### 4.223 Course: Nonlinear Wave Equations [T-MATH-110806]

**Responsible:** Prof. Dr. Wolfgang Reichel  
Prof. Dr. Roland Schnaubelt  

**Organisation:** KIT Department of Mathematics  

**Part of:** M-MATH-105326 - Nonlinear Wave Equations

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<td>Grade to a third</td>
<td>Irregular</td>
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**Prerequisites**  
none
T Course: Nonparametric Statistics [T-MATH-105873]

**Responsible:**
- Dr. rer. nat. Bruno Ebner
- Prof. Dr. Vicky Fasen-Hartmann
- PD Dr. Bernhard Klar
- Prof. Dr. Mathias Trabs

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102910 - Nonparametric Statistics

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**Competence Certificate**
oral exam of ca. 20 minutes
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<th>Recurrence</th>
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<td>Irregular</td>
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**Responsible:** TT-Prof. Dr. Barbara Verfürth

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105764 - Numerical Analysis of Helmholtz Problems
4.226 Course: Numerical Analysis of Neural Networks [T-MATH-113470]

**Responsible:** TT-Prof. Dr. Roland Maier

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-106695 - Numerical Analysis of Neural Networks

<table>
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<tbody>
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<th>Credits</th>
<th>Lecturer</th>
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<td>ST 2024 7700151</td>
<td></td>
<td>Numerical Analysis of Neural Networks Maier</td>
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<tr>
<td>ST 2024 7700152</td>
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<td>Numerical Analysis of Neural Networks Maier</td>
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**Competence Certificate**
oral exam of ca. 30 minutes

**Prerequisites**
none
4.227 Course: Numerical Complex Analysis [T-MATH-112280]

**Responsible:** Prof. Dr. Marlis Hochbruck  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-106063 - Numerical Complex Analysis

<table>
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<th>Expansion</th>
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<td>Irregular</td>
<td>1 terms</td>
<td>1</td>
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</table>

**Competence Certificate**  
oral exam of ca. 20 minutes

**Prerequisites**  
none

**Recommendation**  
Some basic knowledge of Complex Analysis is strongly recommended.
# 4.228 Course: Numerical Linear Algebra for Scientific High Performance Computing [T-MATH-107497]

**Responsible:** Prof. Dr. Hartwig Anzt  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-103709 - Numerical Linear Algebra for Scientific High Performance Computing

<table>
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**Prerequisites**

none
4.229 Course: Numerical Linear Algebra in Image Processing [T-MATH-108402]

**Responsible:** PD Dr. Volker Grimm  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-104058 - Numerical Linear Algebra in Image Processing

<table>
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</table>

**Exams**

| ST 2024 | 00024 | Numerical Linear Algebra in Image Processing | Grimm |

**Prerequisites**
none
### 4.230 Course: Numerical Methods for Differential Equations [T-MATH-105836]

**Responsible:**
- Prof. Dr. Willy Dörfler
- Prof. Dr. Marlis Hochbruck
- Prof. Dr. Tobias Jahnke
- Prof. Dr. Andreas Rieder
- Prof. Dr. Christian Wieners

**Organisation:**
KIT Department of Mathematics

**Part of:**
- M-MATH-102888 - Numerical Methods for Differential Equations

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<th>Numerische Methoden für Differentialgleichungen</th>
<th>4 SWS</th>
<th>Lecture / 🗣</th>
<th>Hochbruck</th>
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<tbody>
<tr>
<td>WT 24/25</td>
<td>0110800</td>
<td>Übungen zu 0110700 (numerische Methoden für Differentialgleichungen)</td>
<td>2 SWS</td>
<td>Practice / 🗣</td>
<td>Hochbruck</td>
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**Exams**

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<th>00020</th>
<th>Numerical Methods for Differential Equations</th>
<th>Wieners</th>
</tr>
</thead>
</table>

Legend: 🖥 Online, 📒 Blended (On-Site/Online), 🗣 On-Site, 🗝 Cancelled
**4.231 Course: Numerical Methods for Hyperbolic Equations [T-MATH-105900]**

- **Responsible:** Prof. Dr. Willy Dörfler
- **Organisation:** KIT Department of Mathematics
- **Part of:** M-MATH-102915 - Numerical Methods for Hyperbolic Equations

<table>
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<td>Grade to a third</td>
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</table>

**Prerequisites**

none
4.232 Course: Numerical Methods for Integral Equations [T-MATH-105901]

**Responsible:** PD Dr. Tilo Arens  
PD Dr. Frank Hettlich  

**Organisation:** KIT Department of Mathematics  

**Part of:** M-MATH-102930 - Numerical Methods for Integral Equations

<table>
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**Events**

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<td>0112610</td>
<td>Tutorial for 0112600 (Numerical Methods for Integral Equations)</td>
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<td>Practice</td>
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Below you will find excerpts from events related to this course:

**Numerical Methods for Integral Equations**  
0112600, WS 24/25, 4 SWS, Open in study portal  
Lecture (V)

**Content**

In this course, we will learn about a number of methods to numerically solve integral equations, such as Nyström, collocation and Galerkin methods. The lectures will be accompanied by a programming practical in which the methods will be implemented and tested.

**Responsible:** Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102931 - Numerical Methods for Maxwell's Equations

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<tr>
<td>Oral examination</td>
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<td>Grade to a third</td>
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</table>
**4.234 Course: Numerical Methods for Oscillatory Differential Equations [T-MATH-113437]**

**Responsible:** Prof. Dr. Tobias Jahnke  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-106682 - Numerical Methods for Oscillatory Differential Equations

<table>
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<td>Grade to a third</td>
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**Competence Certificate**  
oral exam of ca. 30 minutes

**Prerequisites**  
none

**Responsible:** Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102928 - Numerical Methods for Time-Dependent Partial Differential Equations

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<td>Oral examination</td>
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<td>Grade to a third</td>
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Mathematics Master 2016 (Master of Science (M.Sc.))
Module Handbook as of 09/07/2024
Course: Numerical Methods in Computational Electrodynamics [T-MATH-105860]

**Responsible:**  
Prof. Dr. Willy Dörfler  
Prof. Dr. Marlis Hochbruck  
Prof. Dr. Tobias Jahnke  
Prof. Dr. Andreas Rieder  
Prof. Dr. Christian Wieners

**Organisation:**  
KIT Department of Mathematics

**Part of:**  
M-MATH-102894 - Numerical Methods in Computational Electrodynamics

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<td>1</td>
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</tbody>
</table>

**Prerequisites**  
none

**Responsible:** Prof. Dr. Willy Dörfler  
PD Dr. Gudrun Thäter

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102932 - Numerical Methods in Fluid Mechanics

<table>
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<th>Credits</th>
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<th>Version</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Events</th>
<th>Credits</th>
<th>Lecture</th>
<th>Responsible</th>
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<tbody>
<tr>
<td>ST 2024</td>
<td>0161600</td>
<td>Numerical Methods in Fluidmechanics</td>
<td>Dörfler</td>
</tr>
</tbody>
</table>

Below you will find excerpts from events related to this course:

**Numerical Methods in Fluidmechanics**  
0161600, SS 2024, 2 SWS, Language: English, Open in study portal

**Content**

Starting from basics we develop the continuum mechanical model that lead to the fundamental equations for incompressible flows. We will study in more detail potential flows, Stokes flows (on bounded or exterior domains) and (non-turbulent) Navier-Stokes flows. We will sketch existence theory and show how to get numerical solutions with the finite element method, including stability and error estimates.
4.238 Course: Numerical Methods in Mathematical Finance [T-MATH-105865]

**Responsible:** Prof. Dr. Tobias Jahnke

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102901 - Numerical Methods in Mathematical Finance

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<tbody>
<tr>
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<td>0107800</td>
<td>Numerical methods in mathematical finance</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>4 SWS</td>
<td>Lecture</td>
</tr>
<tr>
<td>WT 24/25</td>
<td>0107900</td>
<td>Tutorial for 0107800 (numerical methods for mathematical finance)</td>
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<td></td>
<td>2 SWS</td>
<td>Practice</td>
</tr>
</tbody>
</table>

**Competence Certificate**
oral exam of ca. 30 minutes

**Prerequisites**
none

Below you will find excerpts from events related to this course:

**Numerical methods in mathematical finance**
0107800, WS 24/25, 4 SWS, Language: English, [Open in study portal](#)

**Lecture (V)**

**Content**
An option is a contract which gives its owner the right to buy or sell an underlying asset at a future time at a fixed price. The underlying asset is typically a stock of a company or a commodity, and since its value varies randomly, computing the fair price of the corresponding option is an important and interesting problem which yields a number of mathematical challenges. This lecture provides an introduction to a number of mathematical models for option pricing. The main goal, however, is the construction and analysis of numerical methods which approximate the solution of the corresponding differential equations in a stable, accurate and efficient way. The following topics will be treated:

- Options, arbitrage and other basic concepts
- Black-Scholes equation und Black-Scholes formulas
- Numerical methods for stochastic differential equations
- (Multilevel) Monte Carlo methods
- (Quasi-)Monte Carlo integration
- Numerical methods for Black-Scholes equations
- Numerical methods for American options

Prerequisites: Participants are expected to be familiar with stochastic differential equations, the Ito integral, and the Ito formula. A short introduction to these topics (approx. 25 pages) is provided for those students who wish to acquire the relevant background through self-study. Moreover, programming skills (MATLAB or Python) are strongly recommended for the programming exercises.
Course: Numerical Optimisation Methods [T-MATH-105858]

**Responsible:**
- Prof. Dr. Willy Dörfler
- Prof. Dr. Marlis Hochbruck
- Prof. Dr. Tobias Jahnke
- Prof. Dr. Andreas Rieder
- Prof. Dr. Christian Wieners

**Organisation:**
KIT Department of Mathematics

**Part of:**
M-MATH-102892 - Numerical Optimisation Methods

**Type:** Oral examination

**Credits:** 8

**Grading scale:** Grade to a third

**Version:** 1
**4.240 Course: Numerical Simulation in Molecular Dynamics [T-MATH-110807]**

**Responsible:** PD Dr. Volker Grimm  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-105327 - Numerical Simulation in Molecular Dynamics

<table>
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<td>Irregular</td>
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</table>

**Prerequisites**
none
**4.241 Course: Operations Research in Supply Chain Management [T-WIWI-102715]**

**Responsible:** Prof. Dr. Stefan Nickel  
**Organisation:** KIT Department of Economics and Management  
**Part of:**  
- M-WIWI-101473 - Mathematical Programming  
- M-WIWI-102832 - Operations Research in Supply Chain Management

<table>
<thead>
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<th>Version</th>
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<td>Grade to a third</td>
<td>Irregular</td>
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</table>

**Exams**

| ST 2024 | 7900249 | Operations Research in Supply Chain Management | Nickel |

**Competence Certificate**
The assessment is a 60 minutes written examination (according to §4(2), 1 of the examination regulation).
The examination is held in the term of the lecture and the following lecture.

**Prerequisites**
None

**Recommendation**
Basic knowledge as conveyed in the module Introduction to Operations Research and in the lectures Facility Location and Strategic SCM, Tactical and operational SCM is assumed.

**Annotation**
The course is offered irregularly. Planned lectures for the next three years can be found in the internet at http://dol.ior.kit.edu/english/Courses.php.
4.242 Course: Optical Waveguides and Fibers [T-ETIT-101945]

**Responsible:** Prof. Dr.-Ing. Christian Koos  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100506 - Optical Waveguides and Fibers

<table>
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<td>4</td>
<td>Grade to a third</td>
<td>Each winter term</td>
<td>1</td>
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</table>

**Exams**

| ST 2024 | 7309464 | Optical Waveguides and Fibers | Koos |

**Prerequisites**

none
4.243 Course: Optimal Control and Estimation [T-ETIT-104594]

**Responsible:** Prof. Dr.-Ing. Sören Hohmann  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-102310 - Optimal Control and Estimation

<table>
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<tbody>
<tr>
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<td>3</td>
<td>Grade to a third</td>
<td>Each summer term</td>
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</table>

**Events**

| ST 2024 | 2303162 | Optimale Regelung und Schätzung | 2 SWS | Lecture / 🗣 | Kluwe |

**Exams**

| ST 2024 | 7303162 | Optimal Control and Estimation | Kluwe |

Legend: 🖥 Online, 🔄 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Prerequisites**

none
4.244 Course: Optimisation and Optimal Control for Differential Equations [T-MATH-105864]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102899 - Optimisation and Optimal Control for Differential Equations

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<td>Oral examination</td>
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<td>Grade to a third</td>
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Prerequisites
none
4.245 Course: Optimization in Banach Spaces [T-MATH-105893]

**Responsible:** Prof. Dr. Roland Griesmaier  
PD Dr. Frank Hettlich

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102924 - Optimization in Banach Spaces

<table>
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<td>Oral examination</td>
<td>5</td>
<td>Grade to a third</td>
<td>2</td>
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</tbody>
</table>

**Competence Certificate**
oral examination of approximately 30 minutes

**Prerequisites**
none

**Recommendation**
Some basic knowledge of finite dimensional optimization theory and functional analysis is desirable.
4.246 Course: Optimization of Dynamic Systems [T-ETIT-100685]

**Responsible:** Prof. Dr.-Ing. Sören Hohmann

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-ETIT-100531 - Optimization of Dynamic Systems

<table>
<thead>
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<th>Version</th>
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<td>Written exam</td>
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<td>Grade to a third</td>
<td>Each winter term</td>
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</table>

**Exams**

| ST 2024       | 7303183 | Optimization of Dynamic Systems | Hohmann          |

**Competence Certificate**

The assessment consists of a written exam (120 min) taking place in the recess period.

**Prerequisites**

none
**4.247 Course: Optimization under Uncertainty [T-WIWI-106545]**

**Responsible:** Prof. Dr. Steffen Rebennack

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101413 - Applications of Operations Research

<table>
<thead>
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<th>Recurrence</th>
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<td>Each winter term</td>
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<table>
<thead>
<tr>
<th>Exams</th>
<th>Credits</th>
<th>Course Title</th>
<th>Version</th>
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<tr>
<td>ST 2024</td>
<td>7900309</td>
<td>Optimization under Uncertainty</td>
<td>Rebennack</td>
</tr>
</tbody>
</table>

**Competence Certificate**

The assessment consists of a written exam (60 minutes) according to Section 4(2), 1 of the examination regulation. The exam takes place in every the semester.

**Prerequisites**
None.
### 4.248 Course: Oral Exam - Supplementary Studies on Culture and Society [T-ZAK-112659]

**Responsible:** Dr. Christine Mielke  
Christine Myglas

**Organisation:**  
Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

<table>
<thead>
<tr>
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<th>Grading scale</th>
<th>Version</th>
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<tbody>
<tr>
<td>Oral exam</td>
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<td>Grade to a third</td>
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</table>

**Competence Certificate**
An oral examination according to § 7 section 6 of approx. 45 minutes on the contents of two courses from In-depth Module.

**Prerequisites**
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.
4.249 Course: Oral Exam - Supplementary Studies on Sustainable Development [T-ZAK-112351]

Organisation:
- Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

<table>
<thead>
<tr>
<th>Type</th>
<th>Credits</th>
<th>Grading scale</th>
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<tbody>
<tr>
<td>Oral exam</td>
<td>4</td>
<td>Grade to a third</td>
<td>1</td>
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</tbody>
</table>

Competence Certificate
An oral examination according to § 7 section 6 of approx. 45 minutes on the contents of two courses from Elective Module.

Prerequisites
A requirement for the Supplementary Course: Oral examination is the successful completion of the modules Basics Module and Specialisation Module and the required electives of Elective Module.
4.250 Course: Parallel Computing [T-MATH-102271]

**Responsible:** PD Dr. Mathias Krause
Prof. Dr. Christian Wieners

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-101338 - Parallel Computing

<table>
<thead>
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</thead>
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<tr>
<td>Oral examination</td>
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<td>Grade to a third</td>
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</table>
4.251 Course: Parametric Optimization [T-WIWI-102855]

Responsible: Prof. Dr. Oliver Stein
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101473 - Mathematical Programming

Type: Written examination  Credits: 4.5  Grading scale: Grade to a third  Recurrence: Irregular  Version: 1

Competence Certificate
The assessment of the lecture is a written examination (60 minutes) according to §4(2), 1 of the examination regulation. The successful completion of the exercises is required for admission to the written exam.
The examination is held in the semester of the lecture and in the following semester.

Prerequisites
None

Recommendation
It is strongly recommended to visit at least one lecture from the Bachelor program of this chair before attending this course.

Annotation
The lecture is offered irregularly. The curriculum of the next three years is available online (www.ior.kit.edu).
4.252 Course: Percolation [T-MATH-105869]

**Responsible:**  
Prof. Dr. Daniel Hug  
Prof. Dr. Günter Last  
PD Dr. Steffen Winter  

**Organisation:**  
KIT Department of Mathematics  

**Part of:**  
M-MATH-102905 - Percolation

**Type**  
Oral examination  

**Credits**  
5  

**Grading scale**  
Grade to a third  

**Version**  
2

**Prerequisites**  
none
### 4.253 Course: Photorealistic Rendering [T/INFO-101268]

**Responsible:** Prof. Dr.-Ing. Carsten Dachsbacher  
**Organisation:** KIT Department of Informatics  
**Part of:** M/INFO-100731 - Photorealistic Rendering

<table>
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<tr>
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<td>Each summer term</td>
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**Exams**

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<th>Code</th>
<th>Type</th>
<th>Supervisor</th>
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<td>ST 2024</td>
<td>7500124</td>
<td>Photorealistic Rendering</td>
<td>Dachsbacher</td>
</tr>
</tbody>
</table>
4.254 Course: Physiology and Anatomy for Engineers I [T-ETIT-101932]

**Responsible:** Prof. Dr. Werner Nahm

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-ETIT-100390 - Physiology and Anatomy for Engineers I

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<td>3</td>
<td>Grade to a third</td>
<td>Each winter term</td>
<td>1</td>
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</table>

**Competence Certificate**
Success control is carried out in the form of a written test of 60 minutes.

**Prerequisites**
none
### 4.255 Course: Poisson Processes [T-MATH-105922]

**Responsible:** Prof. Dr. Vicky Fasen-Hartmann  
Prof. Dr. Daniel Hug  
Prof. Dr. Günter Last  
Dr. Franz Nestmann  
PD Dr. Steffen Winter

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102922 - Poisson Processes

<table>
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<td>Oral examination</td>
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<td>Grade to a third</td>
<td>1</td>
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</table>

**Events**

| ST 2024 | 0152700 | Der Poisson-Prozess | 2 SWS | Lecture | Nestmann |

**Exams**

| ST 2024 | 7700011 | Poisson Processes | Nestmann, Last |

**Prerequisites**

none
4.256 Course: Potential Theory [T-MATH-105850]

**Responsible:** PD Dr. Tilo Arens  
Prof. Dr. Roland Griesmaier  
PD Dr. Frank Hettlich  
Prof. Dr. Wolfgang Reichel

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102879 - Potential Theory

<table>
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<tr>
<td>Oral exam</td>
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<td>Grade to a third</td>
<td>1</td>
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</tbody>
</table>
4.257 Course: Practice Module [T-ZAK-112660]

**Responsible:** Dr. Christine Mielke
Christine Myglas

**Organisation:**
- **Part of:** M-ZAK-106235 - Supplementary Studies on Culture and Society

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<tr>
<td>Completed coursework</td>
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<td>pass/fail</td>
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**Competence Certificate**
- Internship (3 ECT)
- Report within the framework of the practical training (Length approx. 18,000 characters (incl. spaces) (1 ECT)

**Prerequisites**
- none

**Annotation**
- Knowledge from the Basic Module and the Elective Module is helpful.

**Responsible:** Prof. Dr. Daniel Hug  
Prof. Dr. Günter Last

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102947 - Probability Theory and Combinatorial Optimization

<table>
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<td>Grade to a third</td>
<td>1</td>
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**Prerequisites**  
none
# 4.259 Course: Process Mining [T-WIWI-109799]

**Responsible:** Prof. Dr. Andreas Oberweis  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics

<table>
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<th>Grading scale</th>
<th>Recurrence</th>
<th>Version</th>
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<td>Grade to a third</td>
<td>Each summer term</td>
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## Events

<table>
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<th>ST 2024</th>
<th>2511204</th>
<th>Process Mining</th>
<th>2 SWS</th>
<th>Lecture / 🗣</th>
<th>Oberweis</th>
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<tbody>
<tr>
<td>ST 2024</td>
<td>2511205</td>
<td>Exercise Process Mining</td>
<td>1 SWS</td>
<td>Practice / 🗣</td>
<td>Oberweis, Schreiber, Schüler, Rybinski</td>
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</table>

## Exams

<table>
<thead>
<tr>
<th>ST 2024</th>
<th>79AIFB_PM_C2</th>
<th>Process Mining (Registration until 15 July 2024)</th>
<th>Oberweis</th>
</tr>
</thead>
</table>

**Legend:** 🖥 Online, ☑️ Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

### Competence Certificate

The assessment of this course is a written examination (60 min) according to §4(2), 1 of the examination regulation in the first week after lecture period.

### Prerequisites

None

### Annotation

Former name (up to winter semester 2018/2019) "Workflow Management".

Below you will find excerpts from events related to this course:

## Process Mining

<table>
<thead>
<tr>
<th>2511204, SS 2024, 2 SWS, Language: German</th>
<th>Open in study portal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture (V)</td>
<td>On-Site</td>
</tr>
</tbody>
</table>
Content
The area of process mining covers approaches which aim at deducting new knowledge on the basis of logfiles generated by information systems. Such information systems are e.g., workflow-management-systems which are used for an efficient control of processes in enterprises and organisations. The lecture introduces the foundations of processes and respective modeling and analysis techniques. In the following, the foundations of process mining and the three classical types of approaches - discovery, conformance and enhancement - will be taught. In addition to the theoretical basics, tools, application scenarios in practice and open research questions are covered as well.

Learning objectives:
Students

- understand the concepts and approaches of process mining and know how they are applied,
- create and evaluate business process models,
- analyze static and dynamic properties of workflows,
- apply approaches and tools of process mining.

Recommendations:
Knowledge of course Applied Informatics - Modelling is expected.

Workload:

- Lecture 30h
- Exercise 15h
- Preparation of lecture 24h
- Preparation of exercises 25h
- Exam preparation 40h
- Exam 1h

Literature


Weitere Literatur wird in der Vorlesung bekannt gegeben.
4.260 Course: Project Lab Cognitive Automobiles and Robots [T-WIWI-109985]

**Responsible:** Prof. Dr.-Ing. Johann Marius Zöllner

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101472 - Informatics

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<thead>
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<th>Grading scale</th>
<th>Recurrence</th>
<th>Version</th>
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</thead>
<tbody>
<tr>
<td>Examination of another type</td>
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<td>Each winter term</td>
<td>3</td>
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**Events**

<table>
<thead>
<tr>
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<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Version</th>
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</thead>
<tbody>
<tr>
<td>WT 24/25</td>
<td>Practical Course Cognitive automobiles and robots (Master)</td>
<td>3 SWS</td>
<td>Practical course / Zöllner, Daaboul</td>
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</tbody>
</table>

**Legend:** 🗿 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Competence Certificate**
The alternative exam assessment consists of:

- a practical work
- a presentation and
- a written seminar thesis

Details of the grade formation will be announced at the beginning of the course.

**Prerequisites**
None

**Below you will find excerpts from events related to this course:**

**Content**
The lab is intended as a practical supplement to courses such as "Machine Learning 1/2". Scientific topics, mostly in the area of autonomous driving and robotics, will be addressed in joint work with ML/KI methods. The goal of the internship is for participants to design, develop, and evaluate ML Software system.

In addition to the scientific goals, such as the study and application of methods, the aspects of project-specific teamwork in research (from specification to presentation of results) are also worked on in this internship.

The individual projects require the analysis of the set task, selection of appropriate methods, specification and implementation and evaluation of the solution approach. Finally, the selected solution is to be documented and presented in a short lecture.

**Learning Objectives:**
- Students will be able to practically apply theoretical knowledge from lectures on machine learning to a selected area of current research.
- Students will be proficient in analyzing and solving thematic problems.
- Students will be able to evaluate, document, and present their concepts and results.

**Recommendations:**
- Theoretical knowledge of machine learning and/or AI.
- Python knowledge
- Initial experience with deep learning frameworks such as PyTorch/Jax/Tensorflow may be beneficial.

**Workload:**
The workload of 5 credit points consists of practical implementation of the selected solution, as well as time for literature research and planning/specification of the selected solution. In addition, a short report and presentation of the work performed will be prepared.
Organizational issues
Anmeldung und weitere Informationen sind im WiWi-Portal zu finden.
Registration and further information can be found in the WiWi-portal.
4.261 Course: Project Lab Machine Learning [T-WIWI-109983]

Responsible: Prof. Dr.-Ing. Johann Marius Zöllner
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

Type: Examination of another type
Credits: 5
Grading scale: Grade to a third
Recurrence: Each summer term
Version: 3

Events

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<td>Each summer term</td>
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Exams

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🔴 On-Site, ✗ Cancelled

Competence Certificate
The alternative exam assessment consists of:
- a practical work
- a presentation and
- a written seminar thesis

Details of the grade formation will be announced at the beginning of the course.

Prerequisites
None

Below you will find excerpts from events related to this course:

Project Lab Machine Learning
2512500, SS 2024, 3 SWS, Language: German/English, Open in study portal

Practical course (P)
Blended (On-Site/Online)

Content
The lab is intended as a practical supplement to lectures such as "Machine Learning". The theoretical basics are applied in the lab course. The aim of the lab course is that the participants work together to design, develop and evaluate a subsystem from the field of robotics and cognitive systems using one or more procedures from the field of AI/ML.

In addition to the scientific objectives involved in the investigation and application of the methods, aspects of project-specific teamwork in research (from specification to presentation of the results) are also developed in this practical course.

The individual projects require the analysis of the task at hand, selection of suitable procedures, specification and implementation and evaluation of the approach taken. Finally, the chosen solution has to be documented and presented in a short presentation.

Learning objectives:
- Students can practically apply knowledge from the Machine Learning lecture in a selected field of current research in robotics or cognitive automobiles.
- Students master the analysis and solution of corresponding problems in a team.
- Students can evaluate, document and present their concepts and results.

Recommendations:
Attendance of the lecture machine learning, C/C++ knowledge, Python knowledge

Workload:
The workload of 5 credit points consists of the time spent in the lab for practical implementation of the selected solution, as well as the time spent on literature research and planning/specifying the proposed solution. In addition, a short report and a presentation of the work carried out will be prepared.
**Organizational issues**
Anmeldung und weitere Informationen sind im WiWi-Portal zu finden.
Registration and further information can be found in the WiWi-portal.
Course: Random Graphs and Networks [T-MATH-112241]

**Responsible:** Prof. Dr. Daniel Hug

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-106052 - Random Graphs and Networks

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**Competence Certificate**
oral exam of ca. 30 min

**Prerequisites**
none

**Recommendation**
The contents of the module 'Probability Theory' are strongly recommended.
Below you will find excerpts from events related to this course:

**Content**

Elliptic operators on $\mathbb{R}^n$ or, complemented by suitable boundary conditions on domains, give rise to sectorial operators in Lebesgue spaces $L^q$.

In this lecture we study certain regularity properties for elliptic operators, e.g. boundedness of an $H^{\infty}$ functional calculus, description of the domains of fractional powers, and maximal $L^p$ regularity for the corresponding parabolic problem.

These properties have applications in the study of partial differential equations, e.g. of parabolic type.
4.264 Course: Riemann Surfaces [T-MATH-113081]

Responsible: Prof. Dr. Frank Herrlich
Organisation: KIT Department of Mathematics
Part of: M-MATH-106466 - Riemann Surfaces

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Competence Certificate
Oral examination of ca. 30 minutes.

Prerequisites
none
**4.265 Course: Robotics I - Introduction to Robotics [T-INFO-108014]**

**Responsible:** Prof. Dr.-Ing. Tamim Asfour  
**Organisation:** KIT Department of Informatics  
**Part of:** M-INFO-100893 - Robotics I - Introduction to Robotics

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**Exams**

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<td>7500218</td>
<td>Robotik I - Einführung in die Robotik</td>
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**Legend:** 🗣 Online, 🦜 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**  
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 120 minutes.

**Prerequisites**  
none.

_Below you will find excerpts from events related to this course:_

**Robotics I - Introduction to Robotics**  
2424152, WS 24/25, SWS, Language: English, [Open in study portal](#)

**Content**  
The lecture provides an overview of the fundamentals of robotics using the examples of industrial robots, service robots and autonomous humanoid robots. An insight into all relevant topics is given. This includes methods and algorithms for robot modeling, control and motion planning, image processing and robot programming. First, mathematical basics and methods for kinematic and dynamic robot modeling, trajectory planning and control as well as algorithms for collision-free motion planning and grasp planning are covered. Subsequently, basics of image processing, intuitive robot programming especially by human demonstration and symbolic planning are presented.

In the exercise, the theoretical contents of the lecture are further illustrated with examples. Students deepen their knowledge of the methods and algorithms by independently working on problems and discussing them in the exercise. In particular, students can gain practical programming experience with tools and software libraries commonly used in robotics.

**Workload:**

Lecture with 3 SWS + 1 SWS Tutorial, 6 LP  
6 LP corresponds to 180 hours, including  
15 * 3= 45 hours attendance time (lecture)  
15 * 1= 15 hours attendance time (tutorial)  
15 * 6= 90 hours self-study and exercise sheets  
30 hours preparation for the exam

**Competency Goals:**

The students are able to apply the presented concepts to simple and realistic tasks from robotics. This includes mastering and deriving the mathematical concepts relevant for robot modeling. Furthermore, the students master the kinematic and dynamic modeling of robot systems, as well as the modeling and design of simple controllers. The students know the algorithmic basics of motion and grasp planning and can apply these algorithms to problems in robotics. They know algorithms from the field of image processing and are able to apply them to problems in robotics. They are able to model and solve tasks as a symbolic planning problem. The students have knowledge about intuitive programming procedures for robots and know procedures for programming and learning by demonstration.
Organizational issues
Die Erfolgskontrolle erfolgt in Form einer schriftlichen Prüfung im Umfang von i.d.R. 120 Minuten nach § 4 Abs. 2 Nr. 1 SPO.

Modul für Bachelor/Master Informatik, Maschinenbau, Mechatronik und Informationstechnik, Elektrotechnik und Informationstechnik

Literature
Weiterführende Literatur
Fu, Gonzalez, Lee: Robotics - Control, Sensing, Vision, and Intelligence
Course: Ruin Theory [T-MATH-108400]

**Responsible:** Prof. Dr. Vicky Fasen-Hartmann

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-104055 - Ruin Theory

**Type:** Oral examination

**Credits:** 4

**Grading scale:** Grade to a third

**Recurrence:** Irregular

**Version:** 1

**Prerequisites:**

none
4.267 Course: Scattering Theory [T-MATH-105855]

**Responsible:** PD Dr. Tilo Arens  
Prof. Dr. Roland Griesmaier  
PD Dr. Frank Hettlich

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102884 - Scattering Theory

<table>
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Mathematics Master 2016 (Master of Science (M.Sc.))  
Module Handbook as of 09/07/2024
4.268 Course: Scattering Theory for Time-dependent Waves [T-MATH-113416]

Responsibility: Prof. Dr. Roland Griesmaier
Organisation: KIT Department of Mathematics
Part of: M-MATH-106664 - Scattering Theory for Time-dependent Waves

<table>
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Competence Certificate
oral exam of ca. 30 min

Prerequisites
none
Organisation: KIT Department of Mathematics
Part of: M-MATH-105897 - Selected Methods in Fluids and Kinetic Equations

Type: Oral examination
Credits: 3
Grading scale: Grade to a third
Recurrence: Irregular
Expansion: 1 terms
Version: 1

Competence Certificate
oral examination of approx. 30 minutes

Prerequisites
none

Recommendation
The courses "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.
4.270 Course: Selected Topics in Cryptography [T-INFO-101373]

**Responsible:** Prof. Dr. Jörn Müller-Quade

**Organisation:** KIT Department of Informatics

**Part of:** M-INFO-100836 - Selected Topics in Cryptography

<table>
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<th>Version</th>
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<td>Grade to a third</td>
<td>Each summer term</td>
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4.271 Course: Selected Topics in Harmonic Analysis [T-MATH-109065]

**Responsible:** Prof. Dr. Dirk Hundertmark

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-104435 - Selected Topics in Harmonic Analysis

<table>
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<td>Grade to a third</td>
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**Prerequisites**
none
**4.272 Course: Self-Booking-HOC-SPZ-ZAK-1-Graded [T-MATH-111515]**

**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-103053 - Key Competences

<table>
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<td>Grade to a third</td>
<td>Each term</td>
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**Self service assignment of supplementary studies**  
This course can be used for self service assignment of grade acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

**Annotation**  
Placeholder for self-booking of a graded interdisciplinary qualification, which was provided at the House of Competence, the “Sprachzentrum” or the Center for Applied Cultural Studies and Studium Generale.
### 4.273 Course: Self-Booking-HOC-SPZ-ZAK-2-Graded [T-MATH-111517]

**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-103053 - Key Competences

<table>
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**Self service assignment of supplementary studies**

This course can be used for self service assignment of grade acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

**Annotation**

Placeholder for self-booking of a graded interdisciplinary qualification, which was provided at the House of Competence, the “Sprachenzentrum” or the Center for Applied Cultural Studies and Studium Generale.
### 4.274 Course: Self-Booking-HOC-SPZ-ZAK-4-Graded [T-MATH-111519]

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<th>KIT Department of Mathematics</th>
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<tbody>
<tr>
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#### Self service assignment of supplementary studies
This course can be used for self service assignment of grade acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

#### Annotation
Placeholder for self-booking of a graded interdisciplinary qualification, which was provided at the House of Competence, the "Sprachenzentrum" or the Center for Applied Cultural Studies and Studium Generale.
Self service assignment of supplementary studies
This course can be used for self service assignment of grade acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

Annotation
Placeholder for self-booking of a graded interdisciplinary qualification, which was provided at the House of Competence, the “Sprachenzentrum” or the Center for Applied Cultural Studies and Studium Generale.
4.276 Course: Self-Booking-HOC-SPZ-ZAK-6-Ungraded [T-MATH-111520]

| Organisation: | KIT Department of Mathematics |
| Part of:      | M-MATH-103053 - Key Competences |

<table>
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<td>Each term</td>
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**Self service assignment of supplementary studies**

This course can be used for self service assignment of grade aquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

**Annotation**

Placeholder for self-booking of a graded interdisciplinary qualification, which was provided at the House of Competence, the "Sprachzentrum" or the Center for Applied Cultural Studies and Studium Generale.
4.277 Course: Self-Booking-HOC-SPZ-ZAK-7-Ungraded [T-MATH-111521]

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-103053 - Key Competences

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**Self service assignment of supplementary studies**

This course can be used for self service assignment of grade acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

**Annotation**

Placeholder for self-booking of a graded interdisciplinary qualification, which was provided at the House of Competence, the "Sprachenzentrum" or the Center for Applied Cultural Studies and Studium Generale.
4.278 Course: Self-Booking-HOC-SPZ-ZAK-8-Ungraded [T-MATH-111522]

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-103053 - Key Competences

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**Self service assignment of supplementary studies**

This course can be used for self service assignment of grade acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

**Annotation**

Placeholder for self-booking of a graded interdisciplinary qualification, which was provided at the House of Competence, the “Sprachenzentrum” or the Center for Applied Cultural Studies and Studium Generale.
4.279 Course: Self-Booking-HOC-SPZ-ZAK-Graded [T-MATH-111518]

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-103053 - Key Competences

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**Self service assignment of supplementary studies**
This course can be used for self service assignment of grade acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

**Annotation**
Placeholder for self-booking of a graded interdisciplinary qualification, which was provided at the House of Competence, the “Sprachenzentrum” or the Center for Applied Cultural Studies and Studium Generale.
4.280 Course: Semantic Web Technologies [T-WIWI-110848]

**Responsible:** Dr.-Ing. Tobias Käfer

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101472 - Informatics

<table>
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### Events

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<th>Semantic Web Technologies</th>
<th>2 SWS</th>
<th>Lecture / 🗣️</th>
<th>Färber, Käfer, Braun, Kinder</th>
</tr>
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<tr>
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<td>2511311</td>
<td>Exercises to Semantic Web Technologies</td>
<td>1 SWS</td>
<td>Practice / 🗣️</td>
<td>Färber, Käfer, Braun, Kinder</td>
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### Exams

| ST 2024 | 79AIFB_SWebT_A4 | Semantic Web Technologies (Registration until 15 July 2024) | Käfer |

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣️ On-Site, ✗ Cancelled

**Competence Certificate**

The assessment consists of an 1h written exam following §4, Abs. 2, 1 of the examination regulation or of an oral exam (20 min) following §4, Abs. 2, 2 of the examination regulation.

The exam takes place every semester and can be repeated at every regular examination date.

**Prerequisites**

None

**Recommendation**

Lectures on Informatics of the Bachelor on Information Systems (Semester 1-4) or equivalent are required.

Below you will find excerpts from events related to this course:

**Semantic Web Technologies**

2511310, SS 2024, 2 SWS, Language: English, [Open in study portal](#)
Content
The aim of the Semantic Web is to make the meaning (semantics) of data on the web usable in intelligent systems, e.g. in e-commerce and internet portals.
Central concepts are the representation of knowledge in form of RDF and ontologies, the access via Linked Data, as well as querying the data by using SPARQL. This lecture provides the foundations of knowledge representation and processing for the corresponding technologies and presents example applications.

The following topics are covered:

- Resource Description Framework (RDF) and RDF Schema (RDFS)
- Web Architecture and Linked Data
- Web Ontology Language (OWL)
- Query language SPARQL
- Rule languages
- Applications

Learning objectives:
The student

- understands the motivation and foundational ideas behind Semantic Web and Linked Data technologies, and is able to analyse and realise systems
- demonstrates basic competency in the areas of data and system integration on the web
- masters advanced knowledge representation scenarios involving ontologies

Recommendations:
Lectures on Informatics of the Bachelor on Information Systems (Semester 1-4) or equivalent are required. Knowledge of modeling with UML is required.

Workload:

- The total workload for this course is approximately 135 hours
- Time of presentness: 45 hours
- Time of preparation and postprocessing: 60 hours
- Exam and exam preparation: 30 hours

Literature

Content
The exercises are related to the lecture Semantic Web Technologies.
Multiple exercises are held that capture the topics, held in the lecture Semantic Web Technologies, and discuss them in detail. Thereby, practical examples are given to the students in order to transfer theoretical aspects into practical implementation.

The following topics are covered:

- Resource Description Framework (RDF) and RDF Schema (RDFS)
- Web Architecture and Linked Data
- Web Ontology Language (OWL)
- Query language SPARQL
- Rule languages
- Applications

Learning objectives:
The student

- understands the motivation and foundational ideas behind Semantic Web and Linked Data technologies, and is able to analyse and realise systems
- demonstrates basic competency in the areas of data and system integration on the web
- masters advanced knowledge representation scenarios involving ontologies

Recommendations:
Lectures on Informatics of the Bachelor on Information Systems (Semester 1-4) or equivalent are required. Knowledge of modeling with UML is required.

Organizational issues
Die Übungen finden im Rahmen der Termine der Blockvorlesung statt.

Literature

Weitere Literatur
### 4.281 Course: Semigroup Theory for the Navier-Stokes Equations [T-MATH-113415]

<table>
<thead>
<tr>
<th><strong>Responsible:</strong></th>
<th>Dr. rer. nat. Patrick Tolksdorf</th>
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<tbody>
<tr>
<td><strong>Organisation:</strong></td>
<td>KIT Department of Mathematics</td>
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<tr>
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**Competence Certificate**
oral exam of ca. 30 min

**Prerequisites**
none
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**Responsibility:** Prof. Dr. Achim Streit

**Organisation:** KIT Department of Informatics

**Part of:** M-INFO-101887 - Seminar Advanced Topics in Parallel Programming
# 4.283 Course: Seminar Mathematics [T-MATH-106541]

**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-103276 - Seminar

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<td>7700026</td>
<td>Seminar Mathematics (Vert.)</td>
<td>Kühnlein</td>
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</table>
4.284 Course: Seminar Mathematics [T-MATH-105686]

**Responsible:** PD Dr. Stefan Kühnlein  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102730 - Seminar

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**Exams**

| ST 2024 | 7700025 | Seminar Mathematics | Kühnlein |
### 4.285 Course: Seminar Mathematics 2 [T-MATH-108020]

**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-103925 - Seminar 2

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**Responsible:** Prof. Dr.-Ing. Sander Wahls

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-ETIT-106675 - Signal Processing with Nonlinear Fourier Transforms and Koopman Operators

### Events

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<th>Signal Processing with Nonlinear Fourier Transforms and Koopman Operators</th>
<th>2 SWS</th>
<th>Lecture / 🗣</th>
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<td>Practice to 2303135 Signal Processing with Nonlinear Fourier Transforms and Koopman Operators</td>
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### Exams

| ST 2024 | 7302135 | Signal Processing with Nonlinear Fourier Transforms and Koopman Operators | Wahls |

**Legend:** 🖥 Online, 🌇 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Competence Certificate**

The examination in this module consists of programming assessments and a graded written examination of 120 minutes.

The programming assignments are either pass or fail. They must be passed during the lecture period for admission to the written examination.

The module grade is the grade of the written exam.

**Prerequisites**

none
4.287 Course: Smart Energy Infrastructure [T-WIWI-107464]

**Responsible:** Dr. Armin Ardone
Dr. Dr. Andrej Marko Pustisek

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101452 - Energy Economics and Technology

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**Exams**

| ST 2024 | 7900228 | Smart Energy Infrastructure NEW | Fichtner |
| ST 2024 | 7981023 | Smart Energy Infrastructure    | Fichtner |

**Competence Certificate**

The assessment consists of a written exam (60 minutes). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.
4.288 Course: Sobolev Spaces [T-MATH-105896]

**Responsible:** Prof. Dr. Roland Schnaubelt  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102926 - Sobolev Spaces

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**Recommendation**

Some basic knowledge of (elementary) linear functional analysis is strongly recommended.
Course: Social Choice Theory [T-WIWI-102859]

**Responsible:** Prof. Dr. Clemens Puppe

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101500 - Microeconomic Theory

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**Events**

| ST 2024 | 2520537 | Social Choice Theory | 2 SWS | Lecture / 📚 | Puppe |
| ST 2024 | 2520539 | Übung zu Social Choice Theory | 1 SWS | Practice / 🗂 | Puppe, Kretz |

**Exams**

| ST 2024 | 7900039 | Social Choice Theory (main date) | Puppe |

**Competence Certificate**

Success is assessed by an alternative exam assessment in the form of an open-book examination lasting 60 minutes. The examination is offered every summer semester.

**Prerequisites**

None

**Below you will find excerpts from events related to this course:**

**Social Choice Theory**

2520537, SS 2024, 2 SWS, Language: English, [Open in study portal](#)

**Lecture (V)**

On-Site

**Content**

How should (political) candidates be elected? What are good ways of merging individual judgments into collective judgments? Social Choice Theory is the systematic study and comparison of how groups and societies can come to collective decisions.

The course offers a rigorous and comprehensive treatment of judgment and preference aggregation as well as voting theory. It is divided into two parts. The first part deals with (general binary) aggregation theory and builds towards a general impossibility result that has the famous Arrow theorem as a corollary. The second part treats voting theory. Among other things, it includes proving the Gibbard-Satterthwaite theorem.

**Literature**

**Main texts:**


**Secondary texts:**

4 COURSES

**Course: Sociotechnical Information Systems Development [T-WIWI-109249]**

**Responsible:** Prof. Dr. Ali Sunyaev

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101472 - Informatics

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<td>Each term</td>
<td>Sunyaev, Leiser</td>
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<td>Each term</td>
<td>Sunyaev, Leiser</td>
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### Exams

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</tr>
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</table>

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ CANCELLED

**Competence Certificate**

The alternative exam assessment consists of an implementation and a final thesis documenting the development and use of the application.

**Prerequisites**

None.

*Below you will find excerpts from events related to this course:*

**Advanced Lab Development of Sociotechnical Information Systems (Bachelor)**

2512400, SS 2024, 3 SWS, Language: German/English, [Open in study portal](#)

**Content**

The aim of the lab is to get to know the development of socio-technical information systems in different application areas. In the event framework, you should develop a suitable solution strategy for your problem alone or in group work, collect requirements, and implement a software artifact based on it (for example, web platform, mobile apps, desktop application). Another focus of the lab is on the subsequent quality assurance and documentation of the implemented software artifact.

Registration information will be announced on the course page.

**Advanced Lab Development of Sociotechnical Information Systems (Master)**

2512401, SS 2024, 3 SWS, Language: German/English, [Open in study portal](#)

**Content**

The aim of the lab is to get to know the development of socio-technical information systems in different application areas. In the event framework, you should develop a suitable solution strategy for your problem alone or in group work, collect requirements, and implement a software artifact based on it (for example, web platform, mobile apps, desktop application). Another focus of the lab is on the subsequent quality assurance and documentation of the implemented software artifact.

Registration information will be announced on the course page.
4.291 Course: Software Quality Management [T-WIWI-102895]

Responsible: Prof. Dr. Andreas Oberweis
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101472 - Informatics

**Type**
- Written examination

**Credits**
- 4,5

**Grading scale**
- Grade to a third

**Recurrence**
- Each summer term

**Version**
- 2

### Events

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<td>Übungen zu Software-Qualitätsmanagement</td>
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<td>Practice / 🗣 Frister, Forell</td>
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</table>

### Exams

|        | 79AIFB_STQM_A5 | Software Quality Management (Registration until 15 July 2024) | Oberweis |

Legend: 🖥 Online, 📦 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**
The assessment of this course is a written examination (60 min) according to §4(2), 1 of the examination regulation in the first week after lecture period.

**Prerequisites**
None

Below you will find excerpts from events related to this course:

### Software Quality Management

<table>
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<tr>
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<th>2511208</th>
<th>SS 2024, 2 SWS, Language: German, Open in study portal</th>
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</thead>
</table>

**Lecture (V) On-Site**

**Content**
This lecture imparts fundamentals of active software quality management (quality planning, quality testing, quality control, quality assurance) and illustrates them with concrete examples, as currently applied in industrial software development. Keywords of the lecture content are: software and software quality, process models, software process quality, ISO 9000-3, CMM(I), BOOTSTRAP, SPICE, software tests.

**Learning objectives:**
Students

- explain the relevant quality models,
- apply methods to evaluate the software quality and evaluate the results,
- know the mail models of software certification, compare and evaluate these models,
- write scientific theses in the area of software quality management and find own solutions for given problems.

**Recommendations:**
Programming knowledge in Java and basic knowledge of computer science are expected.

**Workload:**

- Lecture 30h
- Exercise 15h
- Preparation of lecture 24h
- Preparation of exercises 25h
- Exam preparation 40h
- Exam 1h
Literature

• Helmut Balzert: Lehrbuch der Software-Technik. Spektrum-Verlag 2008
• Peter Liggesmeyer: Software-Qualität, Testen, Analysieren und Verifizieren von Software. Spektrum Akademischer Verlag 2002
• Mauro Pezzè, Michal Young: Software testen und analysieren. Oldenbourg Verlag 2009

Weitere Literatur wird in der Vorlesung bekanntgegeben.
### Course: Space and Time Discretization of Nonlinear Wave Equations [T-MATH-112120]

<table>
<thead>
<tr>
<th>Responsible</th>
<th>Prof. Dr. Marlis Hochbruck</th>
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**Prerequisites**

none
4 COURSES

4.293 Course: Spatial Economics [T-WIWI-103107]

Responsible: Prof. Dr. Ingrid Ott
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101496 - Growth and Agglomeration

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<td>Lecture / On-Site</td>
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Exams

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ⬗ Cancelled

Competence Certificate

Depending on further pandemic developments, the examination will be offered either as an open-book examination, or as a 60-minute written examination.

Prerequisites

None

Recommendation

Basic micro- and macroeconomic knowledge is required, such as that taught in the courses "Economics I" [2600012] and "Economics II" [2600014], attendance of which is strongly recommended (but not mandatory). An interest in quantitative-mathematical modeling is also a prerequisite. Attendance of the course "Introduction to Economic Policy" [2560280] is recommended.

Below you will find excerpts from events related to this course:

V Spatial Economics
2561260, WS 24/25, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site
Content
The course covers the following topics:

- Geography, trade and development
- Geography and economic theory
- Core models of economic geography and empirical evidence
- Agglomeration, home market effect, and spatial wages
- Applications and extensions

Learning objectives:
The student

- analyses how spatial distribution of economic activity is determined.
- uses quantitative methods within the context of economic models.
- has basic knowledge of formal-analytic methods.
- understands the link between economic theory and its empirical applications.
- understands to what extent concentration processes result from agglomeration and dispersion forces.
- is able to determine theory based policy recommendations.

Recommendations:
Basic knowledge of micro- and macroeconomics is assumed, as taught in the courses Economics I [2600012], and Economics II [2600014]. An interest in mathematical modeling is advantageous.

Workload:
The total workload for this course is approximately 135 hours.

- Classes: ca. 30 h
- Self-study: ca. 45 h
- Exam and exam preparation: ca. 60 h

Assessment:
The assessment consists of a written exam (60 minutes) (following §4(2), 1 of the examination regulation).

Literature

Weitere Literatur wird in der Vorlesung bekanntgegeben.
(Further literature will be announced in the lecture.)
4.294 Course: Spatial Stochastics [T-MATH-105867]

**Responsible:** Prof. Dr. Daniel Hug  
Prof. Dr. Günter Last  
PD Dr. Steffen Winter

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102903 - Spatial Stochastics

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**Events**

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<td>Practice</td>
<td>Hug</td>
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</table>

**Prerequisites**

none

Below you will find excerpts from events related to this course:

**Spatial Stochastics**

0105600, WS 24/25, 4 SWS, Language: English, [Open in study portal]

**Content**

**Goal:**
The students are familiar with some basic spatial stochastic processes. They do not only understand how to deal with general properties of distributions, but also know how to describe and apply specific models (Poisson process, Gaussian random fields). They know how to work self-organised and self-reflexive.

**Content:**
- Random sets
- Point processes
- Random measures
- Palm distributions
- Random fields
- Gaussian fields
- Spectral theory of random fields
- Spatial ergodic theorem

**Literature**

Skriptum/Lectures Notes
4.295 Course: Special Topics of Numerical Linear Algebra [T-MATH-105891]

**Responsible:** PD Dr. Volker Grimm  
Prof. Dr. Marlis Hochbruck  
PD Dr. Markus Neher

**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-102920 - Special Topics of Numerical Linear Algebra

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**Exams**

| ST 2024 | 0100083 | Special Topics of Numerical Linear Algebra | Grimm |

**Prerequisites**

none
4.296 Course: Specialisation Module - Self Assignment BeNe [T-ZAK-112346]

**Responsible:** Christine Myglas  
**Organisation:** Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

### Type
Examination of another type

### Credits
6

### Grading scale
Grade to a third

### Version
1

#### Competence Certificate
The monitoring occurs in the form of several supplementary courses, which usually comprise a presentation of the (group) project, a written elaboration of the (group) project as well as an individual term paper, if necessary with appendices (examination performances of other kind according to statutes § 5 section 3 No. 3 or § 7 section 7).

The presentation is usually with the accompanying practice partners, as well as the written paper.

#### Prerequisites
Active participation in all three mandatory components.

#### Self service assignment of supplementary studies
This course can be used for self service assignment of grade acquired from the following study providers:
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

#### Recommendation
Knowledge from 'Basic Module ' and 'Elective Module ' is helpful.
Course: Spectral Theory - Exam [T-MATH-103414]

**Responsible:**
Prof. Dr. Dorothee Frey
PD Dr. Gerd Herzog
apl. Prof. Dr. Peer Kunstmann
Prof. Dr. Roland Schnaubelt
Dr. rer. nat. Patrick Tolksdorf

**Organisation:**
KIT Department of Mathematics

**Part of:**
M-MATH-101768 - Spectral Theory

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**Exams**

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<th>Spectral Theory - Exam</th>
<th>Kunstmann, Frey, Hundertmark, Schnaubelt</th>
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**Competence Certificate**

Oral examination of approx. 30 minutes.

**Prerequisites**

none

---

Below you will find excerpts from events related to this course:

**Spectral Theory**

0163700, SS 2024, 4 SWS, Open in study portal

**Literature**

- J.B. Conway: A Course in Functional Analysis.
- D. Werner: Funktionalanalyse.

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<tr>
<th>Responsible:</th>
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**Responsibility:** Prof. Dr. Tobias Jahnke

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105325 - Splitting Methods for Evolution Equations

**Prerequisites:**
none
4.300 Course: Statistical Learning [T-MATH-111726]

**Responsible:** Prof. Dr. Mathias Trabs

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105840 - Statistical Learning

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**Exams**

| ST 2024  | 7700122 | Statistical Learning  | Ebner    |

**Competence Certificate**
The module will be completed with an oral exam (approx. 30 min).

**Prerequisites**
none

**Recommendation**
The module "Introduction to Stochastics" is recommended. The module "Probability theory" is preferable.
### 4.301 Course: Steins Method with Applications in Statistics [T-MATH-111187]

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**Responsible:** Dr. rer. nat. Bruno Ebner  
Prof. Dr. Daniel Hug

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105579 - Steins Method with Applications in Statistics

**Prerequisites:** none
4.302 Course: Stochastic Control [T-MATH-105871]

**Responsible:** Prof. Dr. Nicole Bäuerle

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102908 - Stochastic Control

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**Prerequisites**

none
4.303 Course: Stochastic Differential Equations [T-MATH-105852]

**Responsible:** Prof. Dr. Dorothee Frey  
Prof. Dr. Roland Schnaubelt

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102881 - Stochastic Differential Equations

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Mathematics Master 2016 (Master of Science (M.Sc.))  
Module Handbook as of 09/07/2024
4.304 Course: Stochastic Geometry [T-MATH-105840]

**Responsible:** Prof. Dr. Daniel Hug  
Prof. Dr. Günter Last  
PD Dr. Steffen Winter

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102865 - Stochastic Geometry

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<td>Tutorial for 0152600 (Stochastic Geometry)</td>
<td>2 SWS</td>
<td>Practice</td>
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<td>Winter</td>
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Below you will find excerpts from events related to this course:

**Stochastic Geometry**  
0152600, SS 2024, 4 SWS, Open in study portal

**Content**

For some idea what this course is about see  
https://www.math.kit.edu/stoch/seite/raeumstoch-lehre/en
4.305 Course: Stochastic Information Processing [T-INFO-101366]

**Responsible:** Prof. Dr.-Ing. Uwe Hanebeck  
**Organisation:** KIT Department of Informatics  
**Part of:** M-INFO-100829 - Stochastic Information Processing

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**Exams**

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**Legend:** 🖥 Online, 📡 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Below you will find excerpts from events related to this course:**

**Stochastic Information Processing**

24113, WS 24/25, 3 SWS, Language: German, Open in study portal

**Content**

In order to handle complex dynamic systems (e.g., in robotics), an in-step estimation of the system's internal state (e.g., position and orientation of the actuator) is required. Such an estimation is ideally based on the system model (e.g., a discretized differential equation describing the system dynamics) and the measurement model (e.g., a nonlinear function that maps the state space to a measurement subspace). Both system and measurement model are uncertain (e.g., include additive or multiplicative noise).

For continuous state spaces, an exact calculation of the probability densities is only possible in a few special cases. In practice, general nonlinear systems are often traced back to these special cases by simplifying assumptions. One extreme is linearization with subsequent application of linear estimation theory. However, this often leads to unsatisfactory results and requires additional heuristic measures. At the other extreme are numerical approximation methods, which only evaluate the desired distribution densities at discrete points in the state space. Although the working principle of these procedures is usually quite simple, a practical implementation often turns out to be difficult and especially for higher-dimensional systems it is computationally complex.

As a middle ground, analytical nonlinear estimation methods would therefore often be desirable. In this lecture the main difficulties in the development of such estimation methods are presented and corresponding solution modules are presented. Based on these building blocks, some analytical estimation methods are discussed in detail as examples, which are very suitable for practical implementation and offer a good compromise between computing effort and performance. Useful applications of these estimation methods are also discussed. Both known methods and the results of current research are presented.

**Organizational issues**

Der Prüfungstermin ist per E-Mail zu vereinbaren.

**Literature**

Weiterführende Literatur

Skript zur Vorlesung
4.306 Course: Stochastic Simulation [T-MATH-112242]

**Responsible:** TT-Prof. Dr. Sebastian Krumscheid  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-106053 - Stochastic Simulation

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**Events**

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</table>

**Competence Certificate**
oral exam of ca. 30 min

**Prerequisites**
none

Below you will find excerpts from events related to this course:

**Stochastic Simulation**

0100027, WS 24/25, 2 SWS, Open in study portal

**Content**
The course covers mathematical concepts and computational tools used to analyze systems with uncertainty arising across various application domains. First, we will address stochastic modelling strategies to represent uncertainty in such systems. Then we will discuss sampling-based methods to assess uncertain system outputs via stochastic simulation techniques. The focus of this course will be on the theoretical foundations of the discussed techniques, as well as their methodological realization as efficient computational tools.

Topics covered include:

- Random variable generation
- Simulation of random processes
- Simulation of Gaussian random fields
- Monte Carlo method; output analysis
- Variance reduction techniques
- Quasi Monte Carlo methods
- Markov Chain Monte Carlo methods (Metropolis-Hasting, Gibbs sampler)

Other topics that may be addressed if time allows, such as rare event simulations, and stochastic optimization using stochastic approximation or simulated annealing.
4.307 Course: Structural Graph Theory [T-MATH-111004]

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<tr>
<th>Responsible</th>
<th>Prof. Dr. Maria Aksenovich</th>
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Prerequisites
none
4.308 Course: Supplement Enterprise Information Systems [T-WIWI-110346]

**Responsible:**  Prof. Dr. Andreas Oberweis

**Organisation:**  KIT Department of Economics and Management

**Part of:**  M-WIWI-101472 - Informatics

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<td>Each term</td>
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**Competence Certificate**
The assessment of this course is a written or (if necessary) oral examination.

**Prerequisites**
None

**Annotation**
This course can be used in particular for the acceptance of external courses whose content is in the broader area of applied informatics, but is not equivalent to another course of this topic.
4.309 Course: Supplement Software- and Systemsengineering [T-WIWI-110372]

**Responsible:** Prof. Dr. Andreas Oberweis

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101472 - Informatics

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<td>Each term</td>
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**Competence Certificate**
The assessment of this course is a written or (if necessary) oral examination.

**Prerequisites**
None

**Annotation**
This course can be used in particular for the acceptance of external courses whose content is in the broader area of software and systems engineering, but cannot assigned to another course of this topic.
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**Responsible:** Prof. Dr. Jörn Müller-Quade  
**Organisation:** KIT Department of Informatics  
**Part of:** M-INFO-100853 - Symmetric Encryption

**Competence Certificate**  
Es wird empfohlen, das Modul Sicherheit zu belegen.
4.311 Course: Tactical and Operational Supply Chain Management [T-WIWI-102714]

**Responsibility:** Prof. Dr. Stefan Nickel

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101413 - Applications of Operations Research

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**Events**

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<td>Nickel</td>
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<td>ST 2024</td>
<td>Übungen zu Taktisches und operatives SCM</td>
<td>1,5 SWS</td>
<td>Pomes, Linner, Hoffmann</td>
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**Exams**

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**Legend:** Online, Blended (On-Site/Online), On-Site, Cancelled

**Competence Certificate**

Depending on further pandemic developments, the exam will be offered either as an open-book exam, or as a written exam (60 min).

The exam takes place in every semester.

Prerequisite for admission to examination is the successful completion of the online assessments.

**Prerequisites**

Prerequisite for admission to examination is the successful completion of the online assessments.

**Recommendation**

None

**Annotation**

The lecture is held in every summer term. The planned lectures and courses for the next three years are announced online.

Below you will find excerpts from events related to this course:

**Tactical and operational SCM**

2550486, SS 2024, 3 SWS, Language: German, Open in study portal

**Lecture (V)**

On-Site

**Content**

The planning of material transport is an essential element of Supply Chain Management. By linking transport connections across different facilities, the material source (production plant) is connected with the material sink (customer). The general supply task can be formulated as follows (cf. Gudehus): For given material flows or shipments, choose the optimal (in terms of minimal costs) distribution and transportation chain from the set of possible logistics chains, which asserts the compliance of delivery times and further constraints. The main goal of the inventory management is the optimal determination of order quantities in terms of minimization of fixed and variable costs subject to resource constraints, supply availability and service level requirements. Similarly, the problem of lot sizing in production considers the determination of the optimal amount of products to be produced in a time slot. The course includes an introduction to basic terms and definitions of Supply Chain Management and a presentation of fundamental quantitative planning models for distribution, vehicle routing, inventory management and lot sizing. Furthermore, case studies from practice will be discussed in detail.

Passing the online exercise is a prerequisite for admission to the exam.
Literature
Weiterführende Literatur

- Domschke: Logistik: Transporte, 5. Auflage, Oldenbourg, 2005
- Ghiani, Laporte, Musmanno: Introduction to Logistics Systems Planning and Control, Wiley, 2004
- Gudehus: Logistik, 3. Auflage, Springer, 2005
4.312 Course: Technical Optics [T-ETIT-100804]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100538 - Technical Optics

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Exams

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Prerequisites
none
Course: Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises [T-PHYS-102544]

Responsible: Prof. Dr. Gudrun Heinrich
Prof. Dr. Kirill Melnikov
Prof. Dr. Milada Margarete Mühlleitner
Prof. Dr. Ulrich Nierste
Prof. Dr. Matthias Steinhauser

Organisation: KIT Department of Physics

Part of: M-PHYS-102033 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, with Exercises

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<td>Lecture / 🗣 Steinhauser</td>
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Legend: 🖥 Online, 🟢 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

Prerequisites
none
Course: Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises [T-PHYS-102546]

Responsible:
- Prof. Dr. Gudrun Heinrich
- Prof. Dr. Kirill Melnikov
- Prof. Dr. Milada Margarete Mühlleitner
- Prof. Dr. Ulrich Nierste
- Prof. Dr. Matthias Steinhauser

Organisation:
- KIT Department of Physics

Part of:
- M-PHYS-102035 - Theoretical Particle Physics I, Fundamentals and Advanced Topics, without Exercises

Type: Oral examination
Credits: 8
Grading scale: Grade to a third
Version: 1

Events

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Prerequisites

none
# 4.315 Course: Theoretical Particle Physics II, with Exercises [T-PHYS-102552]

**Responsible:** Prof. Dr. Gudrun Heinrich  
Prof. Dr. Kirill Melnikov  
Prof. Dr. Milada Margarete Mühlleitner  
Prof. Dr. Ulrich Nierste

**Organisation:** KIT Department of Physics

**Part of:** M-PHYS-102046 - Theoretical Particle Physics II, with Exercises

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**Events**

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<td>Theoretical Particle Physics II</td>
<td>4</td>
<td>Lecture</td>
<td>Nierste</td>
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<td>Exercises to Theoretical Particle Physics II</td>
<td>2</td>
<td>Practice</td>
<td>Nierste, Kretz</td>
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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Prerequisites**

none
4.316 Course: Theoretical Particle Physics II, without Exercises [T-PHYS-102554]

**Responsible:**
- Prof. Dr. Gudrun Heinrich
- Prof. Dr. Kirill Melnikov
- Prof. Dr. Milada Margarete Mühlleitner
- Prof. Dr. Ulrich Nierste

**Organisation:**
KIT Department of Physics

**Part of:**
M-PHYS-102048 - Theoretical Particle Physics II, without Exercises

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**Events**

| ST 2024 | 4025011 | Theoretical Particle Physics II | 4 SWS | Lecture / 🗣 | Nierste |

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Prerequisites**
none
Time Series Analysis

**Content**
A time series is a sequence of data sequentially observed in time. The course provides an introduction to the theory and practice of statistical time series analysis. Topics covered include stationary and non-stationary stochastic processes, autoregressive and moving average (ARMA) models, model selection and estimation, state-space models and the Kalman filter, forecasting and forecast evaluation, and an outline of spectral techniques.
4.318 Course: Topics in Stochastic Optimization [T-WIWI-112109]

Responsible: Prof. Dr. Steffen Rebennack
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-101473 - Mathematical Programming
          M-WIWI-102832 - Operations Research in Supply Chain Management

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<td>Grade to a third</td>
<td>Each winter term</td>
<td>1</td>
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Competence Certificate
Students will be given problem sets on which they work in groups. The problem sets will involve the implementation of the models presented in the course, and exploring features of these models. The groups will present their findings in front of the class. The grading will be based on the presentation.

Recommendation
A solid understanding of Stochastic Optimization and/or Optimization under Uncertainty as well as optimization in general is highly recommended, since we will heavily build upon basics of these areas.

Annotation
Teaching and learning format: Lecture and exercise
4.319 Course: Topological Data Analysis [T-MATH-111031]

**Responsible:** Prof. Dr. Tobias Hartnick  
Prof. Dr. Roman Sauer  

**Organisation:** KIT Department of Mathematics  

**Part of:** M-MATH-105487 - Topological Data Analysis

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**Prerequisites**  
none
4.320 Course: Topological Genomics [T-MATH-112281]

**Responsible:** Dr. Andreas Ott

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-106064 - Topological Genomics

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**Competence Certificate**
oral exam of ca. 20 min

**Prerequisites**
none
### 4.321 Course: Translation Surfaces [T-MATH-112128]

**Responsible:** Prof. Dr. Frank Herrlich

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-105973 - Translation Surfaces

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**Prerequisites**

none
4.322 Course: Traveling Waves [T-MATH-105897]

**Responsible:** Dr. Björn de Rijk
Prof. Dr. Wolfgang Reichel

**Organisation:** KIT Department of Mathematics

**Part of:** M-MATH-102927 - Traveling Waves

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**Competence Certificate**
The module examination takes place in form of an oral exam of about 30 minutes. Please see under "Modulnote" for more information about the bonus regulation.

**Prerequisites**
none

**Recommendation**
The following background is strongly recommended: Analysis 1-4.
### T 4.323 Course: Trustworthy Emerging Technologies [T-WIWI-113026]

**Responsible:** Prof. Dr. Ali Sunyaev  
**Organisation:** KIT Department of Economics and Management  
**Part of:** M-WIWI-101472 - Informatics

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**Events**

| ST 2024 | 2511404 | Trustworthy Emerging Technologies | Lecture / 🧩 | Sunyaev, Lins |

**Exams**

| ST 2024   | 7900185 | Trustworthy Emerging Technologies | Sunyaev       |

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🔴 On-Site, ❌ Cancelled

**Competence Certificate**

Alternative exam assessment (§ 4(2), 3 SPO). Details will be announced in the respective course.
Below you will find excerpts from events related to this course:

**Uncertainty Quantification**
0164400, SS 2024, 2 SWS, Language: English, [Open in study portal](#)

**Lecture (V)**

Content

"There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – there are things we do not know we don't know." (Donald Rumsfeld)

In this class, we learn to deal with the known unknowns, a field called Uncertainty Quantification (UQ). We particularly focus on the propagation of uncertainties (e.g. unknown data, unknown initial or boundary conditions) through models (mostly differential equations) and leave other important questions of UQ (especially inference) aside. Given uncertain input, how uncertain is the output? The uncertainties are modeled as random variables, and thus the solutions of the equations become random variables themselves.

Thus we summarize the necessary foundations of probability theory, with a focus on modeling correlated and uncorrelated random vectors. Further more, we will see that every uncertain parameter becomes a dimension in the problem. We are thus quickly led to high-dimensional problems. Standard numerical methods suffer from the so-called curse of dimensionality, i.e. to reach a certain accuracy one needs excessively many model evaluations. Thus we study the fundamentals of approximation theory.

The first part of the course ("how to do it") gives an overview on techniques that are used. Among these are:

- Sensitivity analysis
- Monte-Carlo methods
- Spectral expansions
- Stochastic Galerkin method
- Collocation methods, sparse grids

The second part of the course ("why to do it like this") deals with the theoretical foundations of these methods. The so-called "curse of dimensionality" leads us to questions from approximation theory. We look back at the very standard numerical algorithms of interpolation and quadrature, and ask how they perform in many dimensions.

Organizational issues

The course will be offered in flipped classroom format. This means that the lectures will be made available as videos; students will also have lecture notes. We meet in presence for the tutorials, and there will also be office hours.
Literature

4.325 Course: Valuation [T-WIWI-102621]

**Responsible:** Prof. Dr. Martin Ruckes

**Organisation:** KIT Department of Economics and Management

**Part of:**
- M-WIWI-101480 - Finance 3
- M-WIWI-101482 - Finance 1
- M-WIWI-101483 - Finance 2

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**Events**

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<td>Valuation</td>
<td>2 SWS</td>
<td>Lecture / 🗣️ Ruckes</td>
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<td>Practice / 🗣️ Ruckes, Luedecke</td>
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**Exams**

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣️ On-Site, ✗ Cancelled

**Competence Certificate**

See German version.

**Prerequisites**

None

**Recommendation**

None

Below you will find excerpts from events related to this course:

**Valuation**

2530212, WS 24/25, 2 SWS, Language: English, [Open in study portal](#)

**Literature**

Weiterführende Literatur

### 4.326 Course: Variational Methods [T-MATH-110302]

**Responsible:** Prof. Dr. Wolfgang Reichel  
**Organisation:** KIT Department of Mathematics  
**Part of:** M-MATH-105093 - Variational Methods

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Exams

| ST 2024  | 7700141 | Variational Methods   | Lamm    |
### 4.327 Course: Wavelets [T-MATH-105838]

<table>
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<th>Prof. Dr. Andreas Rieder</th>
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<td>Part of</td>
<td>M-MATH-102895 - Wavelets</td>
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**Type**
- Oral examination

**Credits**
- 8

**Grading scale**
- Grade to a third

**Recurrence**
- Irregular

**Version**
- 1

**Competence Certificate**
Mündliche Prüfung im Umfang von ca. 30 Minuten.

**Prerequisites**
- none

**Responsible:** TT-Prof. Dr. Julian Thimme

**Organisation:** KIT Department of Economics and Management

**Part of:** M-WIWI-101480 - Finance 3

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**Competence Certificate**
Non exam assessment according to § 4 paragraph 3 of the examination regulation. (Anmerkung: gilt nur für SPO 2015). The grade is made up as follows: 50% result of the project (R-code), 50% presentation of the project.

**Prerequisites**
None

**Recommendation**
The content of the bachelor course Investments is assumed to be known and necessary to follow the course.
4.329 Course: Wildcard 1 [T-MATH-106331]

**Organisation:** University  
**Part of:** M-MATH-103198 - Wildcard

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